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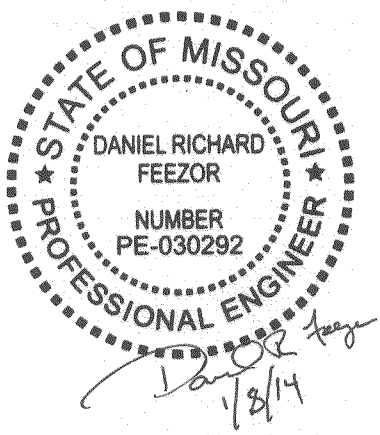
BRIDGETON LANDFILL—WEST LAKE LANDFILL

CORE SAMPLING (PHASE 1B, 1C, and 2)
WORK PLAN - REVISION 1

BRIDGETON, ST. LOUIS COUNTY, MISSOURI



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Core Sampling Work Plan (Phases 1B, 1C and 2) – Revision 1

Bridgeton Landfill, LLC

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1 INTRODUCTION

This document prescribes the location, technology, and methodology to be used to obtain the data necessary to identify a proposed alignment and develop design information for an isolation/thermal barrier. Installation of an isolation/thermal barrier would prevent migration of a subsurface smoldering event (SSE), if one were to ever occur, within Bridgeton Landfill's North Quarry Area into the adjacent Radiological Area 1 of the West Lake Landfill Superfund site.

Bridgeton Landfill is located within an area that contains the permitted Bridgeton Landfill sanitary landfills (the North and South Quarry Landfills) as well as historic West Lake Landfill (pre-regulation and pre-permitting) sanitary and construction and demolition landfills. Of particular note are two portions of the West Lake Landfill, identified as Areas 1 and 2 where in 1973, soil mixed with leached barium sulfate residue was placed as daily or intermediate cover material over and within solid waste disposed in these areas. The resultant mixture of solid waste mixed with soil containing leached barium sulfate residue is termed radiologically-impacted material or simply RIM. Areas 1 and 2 have been identified by the Environmental Protection Agency (EPA) as Operable Unit 1 of the West Lake Landfill Superfund Site. Remedial actions to address the RIM occurrences within Area 1 and 2 are being directed by EPA (EPA-2008 and EMSI, 2011).

A SSE is occurring at depth within the South Quarry Landfill. Bridgeton Landfill, LLC has implemented measures such as installation of an ethylene vinyl alcohol cap, installation of additional landfill gas extraction wells, installation and monitoring of temperature probes, and other activities to address the occurrence of an SSE in the South Quarry Landfill. Bridgeton Landfill, LLC is also evaluating potential options for construction of an isolation/thermal barrier to be installed between the North Quarry Landfill and the adjacent Area 1. Bridgeton Landfill, LLC is evaluating these measures as a means to ensure that in the unlikely event that the SSE in the South Quarry Landfill were to spread to, or otherwise occur within the North Quarry Landfill, it could not expand into Area 1.

Prior investigations (RMC, 1982; NRC, 1988; McLaren/Hart, 1996a; and EMSI, 2000 and 2011) provided data that were used to estimate the extent of RIM in Area 1. Data obtained by these investigations indicate that the RIM was present beneath the northern portion of Area 1 and did not extend to the southern portion of Area 1, near the boundary with the adjacent North Quarry Landfill. Bridgeton Landfill, LLC previously determined that placement of an isolation/thermal barrier within Area 1, but outside of the extent of RIM, would be the optimal location for such a barrier. Placement of the isolation/thermal barrier within the southern portion of Area 1 would minimize the depth to which the isolation/thermal barrier would need to be constructed and minimize the amount of refuse that would otherwise need to be excavated and therefore result in reduced time, cost and potential impacts associated with construction of the isolation/thermal barrier.

To this end, Bridgeton Landfill, LLC previously prepared and submitted a Gamma Cone Penetration Test Work Plan (FEI, 2013) to EPA and subject to EPA approval is in the process of performing a detailed subsurface investigation in the southern portion of Area 1. The purpose of this investigation is to identify the optimum location and obtain geotechnical data for an isolation/thermal barrier to be located between Area 1 and the adjacent Bridgeton Landfill - North Quarry Area. This work is being conducted in accordance with EPA's September 20, 2013, letter directing the investigation under the Additional Work provision of the Administrative Order on Consent for the West Lake OU-1 Superfund Site.

A Phase 1 GCPT investigation was recently conducted in the southern portion of Area 1 (FEI, 2013). The purpose of the Phase 1 investigation was to provide initial field screening level data regarding the possible presence of RIM and to provide initial geotechnical data regarding subsurface conditions along potential alignments for the isolation/thermal barrier. A description of the Phase 1 investigation is provided later in this work plan. Results obtained by the Phase 1 investigation are still being evaluated; however, initial review of the field data indicated that RIM may be present beneath the southwestern portion of Area 1 beneath the anticipated western portion of possible alignments for the isolation/thermal barrier. Furthermore, some of the GCPT soundings in the eastern portion of Area 1 encountered refusal at depths shallower than anticipated and therefore it is unclear whether these borings actually reached the base of refuse. Therefore, although originally it was anticipated that the next step in the investigation would be a Phase 2 investigation to obtain specific data along the proposed alignment of an isolation/thermal barrier, based on initial review of the Phase 1 results, it is clear that additional investigation is necessary in order to select an appropriate alignment for an isolation/thermal barrier.

This Work Plan describes the scope and procedures to be employed for the next phase (Phase 1B) of the investigation. In the interest of providing an overview of all anticipated work and to potentially accelerate the overall review time and minimize downtime between the various phases of work, this work plan also describes the anticipated scope of expected subsequent phases of the investigation (e.g., Phase 1C and Phase 2 investigations).

1.1 PROJECT APPROACH

1.1.1 Site Conditions

In the 1970's West Lake Landfill received various solid and industrial wastes, including soil mixed with leached barium sulfate residues containing traces of uranium, thorium and their long-lived daughter products. The presence of the RIM resulted in the West Lake Landfill being designated as a Superfund site. The RIM is located in two areas at the site: Area 1, which is adjacent to the North Quarry Landfill and thus is pertinent to this investigation; and Area 2, which is located along the northern portion of the site. Area 2 is approximately 1,000 feet (at the closest) from the outer boundary of the North Quarry Area and is separated from it by a road and a closed demolition landfill (Figure 1). Collectively, these two areas have been

designated as Operable Unit 1 for the Superfund investigation and remediation activities while the rest of the site was designated as Operable Unit 2.

The southern border of Area 1 is contiguou s to the waste mass of Bridgeton Landfill, a quarry -fill landfill containing municipal waste. At the present time, Bridgeton Landfill is experiencing a SSE in its South Quarry Area. While the SSE is currently a significant distance from OU -1 Area 1, Bridgeton Landfill wishes to develop a response strategy to ensure that the SSE does not spread into the Area 1 RIM. Bridgeton Landfill, LLC has committed to constructing a subsurface isolation/thermal barrier located between Bridgeton Landfill's waste mass a nd the RIM located within West Lake OU-1 Area 1. As directed by EPA, this work will be conducted pursuant to an Administrative Agreement and Order on Consent with EPA.

For purposes of this Work Plan, and in accordance with previous determinations, direction and guidance from EPA (EPA, 1997, 1998, 2010 and 2013, and EMSI, 2011) RIM will refer to waste material containing radionuclides at levels above those deemed appropri ate for unrestricted use. Specifically, RIM will include materials that contain combined radium -226 and radium-228 at levels greater than 5 pCi/g above background (e.g., 7.9 pCi/g); combined thorium -230 and thorium-232 at levels greater than 5 pCi/g above background (e.g., 7.9 pCi/g); and total uranium greater than 50 pCi/g plus background (e.g. 54.5 pCi/g) [EMSI, 2011].

1.1.2 Proposed Isolation/Thermal Barrier

Bridgeton Landfill has evaluated the possibility of an isolation/thermal barrier as a contingent action to prevent an SSE from advancing from the North Quarry Landfill into the RIM in West Lake OU-1 Area 1. Specifically, Bridgeton Landfill evaluated the excavation of waste to create an isolation/thermal barrier south of the southern limit of radiologically impacted material in Area 1. Such an approach would also limit the volume of waste excavation, consistent with concerns raised by the Lambert -St. Louis International Airport Authority. Finally the relative speed of construction, about three months, w ould allow such a system to be implemented quickly.

Conceptual evaluation of isolation/thermal barrier designs, reported in the March 29, 2013, letter to Ms. Fitch of the Missouri Department of Natural Resources (MDNR) from Craig Almanza, identified pote ntial alignments along which the isolation/thermal barrier could be constructed. The conceptual evaluation also identified that the amount of material requiring excavation and the depth of such a barrier would be substantially lessened – along with all th e negative impacts associated with waste excavation – if the isolation/thermal barrier alignment were moved toward the north. This would allow avoidance of the existing slopes of the North Quarry fill and would reduce the depth of excavation along the eastern portion of the alignment, where quarry activity followed by landfilling would require a much deeper excavation the farther south the isolation/thermal barrier is located.

It is envisioned that the isolation/thermal barrier would be excavated in the non -RIM portions of Area 1, and the purpose of the Ph ase 1 and Phase 2 Investigations is to identify the

alignment for such a location. Alternative methods exist for installation of an isolation/thermal barrier including slurry placement of barrier materials, installation of heat removal/cooling systems, or other techniques. Detailed construction plans for the Isolation/thermal barrier would be submitted for EPA review following conclusion of the investigation work directed by EPA's September 20, 2013 letter (EPA, 2013a).

1.1.3 Overall Scope and Approach of the Investigation

In order to select an alignment and develop the design plans for the isolation/thermal barrier, additional subsurface data are needed for the area between the known extent of the RIM within West Lake OU -1 Area 1 and the Bridgeton Landfill - North Quarry Area. Phase 1 of the project used Cone Penetration Tests (CPTs) to determine the characteristics of the subsurface materials within proposed alignments of the isolation/thermal barrier and the southern edge of the Area 1 fence. The CPT devic e was also capable of measuring subsurface gamma counts which can increase the likelihood that the proposed isolation/thermal barrier can be constructed without encountering RIM. Regardless of the investigation results, radiological scanning will occur during excavation to construct the isolation/thermal barrier to ensure RIM is not being relocated.

Consistent with EPA direction , the Phase 1 Gamma Cone Penetration Test (GCPT) investigation was the first of what was initially envisioned as a two phased in vestigation to confirm the isolation/thermal barrier location. The Phase 1 GCPT investigation was to be used to identify a potential alignment and obtain initial geotechnical data for a potential isolation/thermal barrier and was to be followed by a Phase 2 investigation that would confirm the results obtained from the Phase 1 GCPT investigation and further verify the suitability of the proposed alignment. The assumption underlying this approach was that the initial phase (Phase 1 GCPT) of work would not encounter RIM beneath the area of the potential alignment of the isolation/thermal barrier.

Review of the results of the Phase 1 GCPT investigation indicated that RIM may be present beneath the southwestern portion of Area 1 in the area of possible preferr ed alignments for an isolation/thermal barrier. Elevated gamma readings were obtained from depth intervals of approximately 25 to 35 feet (ft) below ground surface (bgs) in ten (10) of the GCPT soundings drilled in the southwestern portion of Area 1. Spe cifically, elevated gamma counts were reported in GCPT soundings 1.2, 2.2, 2.3, 3.1, 4.1, 4.2, 5.1, 5.2, 5.3, and 6.3 (Figure 2). The occurrence of RIM in this area was previously unknown as this area falls between approximately seven (7) of the soil borin gs drilled, downhole -gamma-logged, sampled, and tested for radionuclide occurrences in conjunction with performance of the Remedial Investigation for OU -1 (EMSI, 2000). Furthermore, the depths at which these materials were encountered (e.g., 25 – 35 ft bgs) were sufficiently great that the overlying solid waste provided sufficient shielding such that these materials were not identified by the overland gamma surveys conducted by the NRC (RMC, 1982) or in conjunction with the RI work (McLaren Hart, 1996b) or by the aerial survey recently conducted by EPA (EPA, 2013b).

Because initial evaluation of the results of the Phase 1 GCPT investigation suggest that RIM may be present beneath the southwestern portion of Area 1, additional investigations prior to identification of a potential alignment for an isolation/thermal barrier are needed. Borehole drilling and collection and laboratory analyses of soil/waste samples from this area are necessary to obtain information regarding the nature of the waste materials ass ociated with the Phase 1 GCPT elevated gamma readings and to verify that the elevated gamma levels reported in borings drilled in the southwestern portion of Area 1 reflect the presence of RIM (in contrast to the possible presence of some other material) in this area. In addition, as previously indicated, many of the GCPT soundings drilled in the southeastern portion of Area 1 (e.g., GCPT soundings along alignments 13, 14 and portions of 15 – see Figure 2) encountered refusal at shallow depths.

Consequently, an additional phase (Phase 1B) of investigation is proposed prior to identification of a potential alignment for an isolation/thermal barrier. Phase 1B work would include drilling of additional borings, downhole gamma logging in the borings, and samp ling the material responsible for the elevated gamma readings observed in the Phase 1 GCPT borings drilled in the area. Assessing why many of the GCPT soundings drilled during Phase 1 along the east side of the southern portion of Area 1 encountered refus al at shallow depths would also be conducted during Phase 1B. Assuming the material responsible for the elevated gamma readings in the southwestern portion of Area 1 is RIM, a subsequent phase of investigation (Phase 1C) is also envisioned to define the l imits of this RIM prior to selection of an alignment for an isolation/thermal barrier. A Phase 2 core sampling investigation would confirm the characteristics (concentrations of isotopic elements, geotechnical data, and nature of fill materials) of the subsurface material along the proposed isolation/thermal barrier alignment.

This Work Plan, along with a corresponding Health and Safety Plan (HASP), is being submitted to detail the locations and procedures to be used to drill soil borings, collect core sam ples, and perform radioisotope analyses of selected core samples during the Phase 1B investigation. The procedures described in this plan and the previous GCPT Work Plan (FEI, 2013) are also appropriate for work anticipated to be performed as part of the Phase 1C and Phase 2 investigations.

1.2 GOALS OF THE INVESTIGATION

The goals and objectives and overall scope of the various phases of the investigation are described below. To minimize delay between the various phases of the investigations, the EPA has requested an expedited development of a Work Plan that addresses the additional Phase 1 investigations and the Phase 2 investigation. At the time this work plan is being authored, the results of the Phase 1 GCPT work are still being evaluated. Therefore, t his work plan is focused on the scope and procedures to be utilized to conduct the Phase 1B investigation. In order to expedite performance of the subsequent investigations, this work plan also describes the general scope and anticipated approach envision ed for the subsequent phases of the

investigation. The procedures and protocols described in this work plan and the previous Phase 1 GCPT work plan (FEI, 2013) will also be used for the subsequent Phase 1C and Phase 2 investigations. The actual boring locations, drilling techniques (whether GCPT or soil/waste coring) to be used in the subsequent investigations have not been finalized at this time. Addenda to this work plan will be developed to describe the specific drilling locations, drilling and sampling techniques, and other aspects of the Phase 1C and Phase 2 work based on the results of the Phase 1 GCPT and Phase 1B investigations. These addenda will be submitted to EPA once the specific drilling locations and methodologies have been selected for the subsequent phases of work. It is the intention of Bridgeton Landfill, LLC and EPA to expedite the development and approval of these amendments so as to maximize the potential for continuous, uninterrupted investigation and design of an isolation/thermal barrier to the extent possible.

1.2.1 Phase 1 GCPT

Phase 1 of the investigation was focused on collection of information south of and, in some locations, up to the projected extent of RIM material occurrences, in order to confirm the absence of RIM in the location selected for the potential isolation/thermal barrier alignment. The goals of the Phase 1 investigation were to provide confirmatory observations that material within the proposed excavation area for the potential isolation/thermal barrier alignment does not contain RIM and to gather the required geotechnical data for design of the barrier.

The primary goals of the GCPT investigation (Phase 1) were to:

- Determine the stratigraphy, nature, and geotechnical properties of subsurface materials for design purposes,
- Determine liquid levels,
- Determine if any RIM exists within the potential isolation/thermal barrier excavation footprint,
- Determine depth to native material, and
- Use the above information to select the best alignment for the isolation/thermal barrier (proposed alignment).

1.2.2 Phase 1B – Completion/Confirmation Investigation

Initial review of the results of the Phase 1 investigation indicates that previously unidentified RIM may be present beneath the southwestern portion of Area 1. Specifically, elevated gamma readings were measured in GCPT soundings drilled in the southwestern portion of Area 1. One of the goals of the Phase 1B investigation is to obtain samples for laboratory analyses of the eight known isotopes associated with the RIM in OU-1. Therefore, Phase 1B will include drilling of soil borings, performance of downhole gamma logging of the soil borings, collection of samples of the specific material responsible for the elevated gamma readings observed in the Phase 1 GCPT soundings drilled in this area, visual inspection and description of the material

associated with the elevated gamma readings, and submission of samples to an offsite analytical laboratory for radioisotope analyses.

Furthermore, many of the GCPT soundings drilled along the east side of the southern portion of Area 1 (e.g., those included in alignments 13 and 14 – see Figure 2) encountered refusal at shallow depths. The cause of this refusal could not be determined from the GCPT work. It may be due to the presence of construction and demolition debris in this area or alternatively may reflect the pres ence of shallow bedrock in this area. Data regarding the base of the OU -1 landfill wastes are needed in this area. Therefore, additional drilling is required to evaluate the nature of the materials responsible for GCPT refusal in this area and to verify the absence of RIM as well as obtain geotechnical data necessary for selection of a potential alignment for an isolation/thermal barrier through this area (i.e., to complete the objectives of Phase 1). Therefore, several soil borings will be drilled in th is area using a drilling method that should be capable of drilling through any construction and demolition debris or the upper portion of any bedrock that may be present in this area to ensure that drilling extends through the entire thickness of refuse in this area.

It also necessary to obtain laboratory analytical data from known, unimpacted boring locations to assist with determination of background gamma levels and radioisotope activities associated with non -RIM waste and in situ soils. Therefore, so il/waste samples will be obtained from Phase 1B borings drilled in the eastern portion of Area 1 that do not display elevated downhole gamma readings. Samples will also be obtained from any borings/depth intervals where elevated gamma readings are encount ered in the boreholes drilled in the eastern portion of Area 1.

1.2.3 Phase 1C – Delineation of the Extent of RIM

In order to select a proposed alignment for an isolation/thermal barrier, additional characterization of the area of elevated gamma readings in the southwestern portion of Area 1 will likely need to be performed, presuming that the results of the Phase 1B investigation indicate that these readings reflect the presence of RIM in this area. Although the logical approach for such an investigation would be to perform additional GCPT soundings outside of this area, use of the GCPT drilling technique may not ensure complete delineation of the extent of elevated gamma readings in this area. Besides the potential for refusal at depths less than the full dept h of refuse as encountered in the eastern portion of Area 1, drilling to define the extent of RIM may necessitate drilling along and through the slope of the North Quarry Landfill, the waste deposits of which overlap the southernmost portion of Area 1. Th e depth of drilling required in this area could potentially exceed the maximum effective depth of the GCPT drilling rig (approximately 70 to 100 ft). Therefore, delineation of the extent of possible RIM in the southwestern portion of Area 1 may require pe rformance of sonic drilling or a combination of GCPT and sonic drilling. The proposed approach for completion of this delineation will be addressed in an addendum to this Workplan.

1.2.4 Phase 2 Core Sampling Investigation

The objective of Phase 2 of this proje ct is to collect soil core samples from a limited number of locations and analyze the samples for the presence or absence of RIM as well as to confirm the characteristics of the subsurface material along the proposed isolation/thermal barrier alignment determined from the G CPT. The Phase 2 investigation will also be used as a verification of the GCPT methodology and interpretations for the geotechnical data.

Based on the results of the Phase 1 investigations, an initial conceptual design for an isolation/thermal barrier will be developed. The initial conceptual design will include a summary and evaluation of the Phase 1 investigation results, a proposed alignment for the isolation/thermal barrier, the anticipated barrier technology, and the general ap proach anticipated to be used for installation of the barrier. Based on the initial conceptual design, additional data necessary for finalization of the proposed alignment, isolation/thermal barrier design and construction techniques will be identified. Currently it is anticipated that the isolation/thermal barrier will be installed by excavation of refuse followed by placement of an earthen barrier along the north side of the excavation, followed by backfilling of the remainder of the excavation with ref use removed from other portions of the excavation. Upon completion, the EVOH cap being installed over the North Quarry Landfill will be extended over the isolation/thermal barrier and excavation areas.

Assuming the isolation/thermal barrier is constructed by excavation of existing refuse, t he primary goal of the Phase 2 core sampling investigation will be to q uantify subsurface concentrations of isotopic elements within the isolation/thermal barrier construction area. This will involve:

- Installation of a sufficient number of boreholes to verify the GCPT data within the isolation/thermal barrier excavation limits~~;~~
- Produce geophysical and radiometric logging data from each soil core;
- Collect samples of soil materials from each length of the borehole (minimum 2 per borehole);
- Generate downhole gamma logs that will be used to prioritize sample analysis from the borehole samples collected;
- Submit soil samples to a certified, independent laboratory for radioanalyses;
- Determine type of waste/subsurface material (e.g., rock, municipal solid waste, construction and demolition waste); and
- Determine the necessary chemical analyses of the Investigation Derived Wastes, so that the soil cores may be properly disposed after all analytical testing has concluded.

The design process will use the results of the Phase 1 investigations to conceptually design the isolation/thermal barrier. Data such as depth of waste, liquid levels, width of isolation/thermal barrier, allowable slopes, and staging requirements will be used in th e alignment and “daylight” line projections, which will guide the coring location selection.

2 PREVIOUS INVESTIGATIONS

Previous investigations in the vicinity of a potential alignment for a subsurface isolation/thermal barrier between Area 1 and the Bridgeton Landfill North Quarry Area did not contemplate construction of a physical structure; therefore, geotechnical data necessary to design a barrier does not exist. However, previous investigations have identified the presence of RIM in Area 1 of the West Lake Landfill using downhole gamma radiation logging of soil borings, collection and analyses of surface and subsurface soil samples, and overland gamma surveys.

2.1 PRIOR INVESTIGATION METHODS

Downhole gamma radiation logging and overland gamma surveys were used as the primary RIM detection methods for these investigations. In addition, samples were collected from soil borings for analyses of uranium, radium, thorium isotopes and their decay products as well as for non-radiological constituents. Results of these investigations are presented in the Soil Boring/Surface Sample Investigation Report (McLaren/Hart, 1996a) and the OU-1 Remedial Investigation Report (EMSI, 2000). Eight radionuclides were identified as contaminants of concern based on their long half-lives: Uranium-238, Uranium-234, Thorium-230, Radium-226 and Lead-210 from the Uranium-238 decay series; Uranium-235 and Protactinium-231 from the Uranium-235 decay series, as well as Thorium-232 and its progeny. Isotopes from the Thorium-232 decay series are also present at levels above background, although to a lesser extent.

2.2 RESULTS OF PREVIOUS INVESTIGATIONS IN AREA 1

Downhole gamma logging by McLaren/Hart in Area 1 found elevated radiation levels varying from zero to sixteen feet bgs, while the thickness of the materials generally ranged from one to five feet in Area 1. In the northwest region of Area 1, elevated readings ranged from zero to six feet bgs, while to the southeast, elevated readings were found as deep as 15 feet bgs. The estimated extent of the impacted area is illustrated in Figure 2.

An overland gamma survey (McLaren/Hart, 1996b) also detected gamma radiation above background at the ground surface. Laboratory analyses of surface soil samples (the upper 6 inches) detected radionuclides at levels above 5 pCi/g above background at boring locations WL-106 and WL-114.

The 2011 Supplemental Feasibility Study (SFS) [EMSI, 2011] included a detailed estimate of the extent of RIM in Area 1. An outline of the known impacted material was created using the available boring data, as well as an outline of the known non-impacted area (see SFS Appendix B-2, Figures 3 and 4). Based on these boundary conditions, the estimated limit of the RIM in Area 1 was interpolated between these two boundaries. These boundaries, the interpolated RIM limits, and borings used to estimate the limits are shown in Figure 2 of this Work Plan.

The SFS delineation of the extent of RIM w as sufficient for purposes of developing and evaluating potential remedial alternatives for OU -1. However, construction of the isolation/thermal barrier requires a high degree of confidence that the alignment for the isolation/thermal barrier is located o utside of the extent of RIM. Therefore, as part of geotechnical investigation of the proposed alignment, data are also being obtained to confirm that the selected alignment is outside the location of RIM above levels for unrestricted use.

3 GCPT INVESTIGATION (PHASE 1)

The scope of the Phase 1 GCPT Investigation was detailed in the September 27, 2013, document entitled "Bridgeton Landfill – West Lake Landfill Gamma Cone Penetration Test (GCPT) Work Plan Revision 2" prepared by Feezor Engineering, Inc., P.J. Carey and Associates, Engineering Management Support, Inc., and Auxier and Associates, Inc. This work plan described the procedures and protocols to advance a piezocone sounding in an area between the known RIM area in Area 1 of OU-1, and the southern edge of OU-1 Area 1. During the investigation, data regarding the stratigraphy, nature, and geotechnical properties of the materials as well as liquid levels, as they relate to the design of a isolation/thermal barrier system were collected with each piezocone sounding. In the same CPT sounding, gamma radiation logging was performed using a proprietary device that is included in the equipment tool string behind the GCPT head. The device used a Cesium Iodide crystal. The device differs from a typical downhole logging gamma detector in that it is part of the push rod system and therefore has greater shielding from the thicker rod walls and is smaller in diameter for the same reason. However the device has been used successfully on other projects to detect the differences between clays and silts.

Tip force, sleeve force and pressure were all recorded as the push rods were advanced. Reading intervals were taken at intervals not exceeding 50 mm. The advance rate of the probe was approximately 2 cm/second, which is the American Society for Testing and Materials (ASTM) Standard.

The type of soils, including waste materials, was inferred based on the analysis of the combination of tip, sleeve and pore pressure while advancing (referred to as dynamic pore pressure). Work at other sites has demonstrated that interfaces between waste material and natural soil can be identified using CPT technology.

The activities described in the approved work plan involved conducting an overland gamma scan in the area between the known RIM area in Area 1 of OU-1 and the southern edge of OU-1 Area 1, clearing brush and vegetation to deploy a geotextile and stone to provide all-weather roadways for investigative equipment, advancing GCPT borings, and evaluating results. All equipment and personnel followed the radiological screening and safety protocols as discussed with the Phase 1 work plan and complementary HASP.

Initial results of the Phase I GCPT work are presented on Figure 2. Initial review of the results of the gamma logging of the GCPT soundings indicate that elevated gamma readings were present in some of the GCPT soundings drilled in the southwestern portion of Area 1 and to the west of the previous OU-1 western boundary. Borings with reported elevated downhole gamma readings include the following:

- GCPT 1.2
- GCPT 2.2
- GCPT 2.3

- GCPT 3.1
- GCPT 4.1
- GCPT 4.2
- GCPT 5.1
- GCPT 5.2
- GCPT 5.3
- GCPT 6.3
- GCPT 8.1 (possible)
- WL-119 (possible)

Subject to the results of the Phase 1B drilling program, additional drilling may be necessary to further delineate the extent of elevated gamma levels/RIM in this area.

Please note that the following soundings warrant additional investigation once the analytical data are obtained from the Phase 1B investigation, as the gamma counts pertain to the background level. These sounding include the following:

- GCPT 7.3
- GCPT 11.4
- GCPT 15.1
- GCPT 15.3

Also note that other GCPT soundings encountered elevated gamma counts which were not unexpected due to their proximity to known RIM boundaries. These include the following:

- GCPT 12.1
- GCPT 13.1
- GCPT 14.1
- PVC 25
- PVC-28
- PVC 36 (also called GCPT 6.1)

As previously discussed, a number of borings along the eastern side of Area 1 encountered refusal at shallow depths and therefore may not have reached the base of refuse. Borings that encountered shallow refusal include the following:

- GCPT 13.2
- GCPT 13.3
- GCPT 13.4
- GCPT 13.5
- GCPT 13.6
- GCPT 13.7
- GCPT 14.2

- GCPT 14.3
- GCPT 14.4
- GCPT 14.5
- GCPT 14.7
- GCPT 15.2
- GCPT 15.8 (Possible)
- GCPT 16.3 (Possible)
- GCPT 16.4 (Possible)
- GCPT 16.5 (Possible)
- GCPT 16.6 (Possible)
- GCPT 16.7 (Possible)
- GCPT 16.8 (Possible)

Additional drilling will be needed to assess the source of the refusal encountered in these borings (i.e., shallow bedrock, construction and demolition debris, other material) and to determine the depth of refuse in this area.

4 PROPOSED INVESTIGATIONS

4.1 OVERVIEW OF TECHNIQUE

As stated previously, the purpose of the GCPT investigation is to verify the absence of RIM in the area where excavation would be performed to construct an isolation/thermal barrier . The GCPT investigation will provide qualitative data regarding the presence and nature of the materials encountered and was not intended to be quantitative. After review of the initial data obtained from the GCPT investigation (Phase 1), the proposed location for the isolation/thermal barrier will be determined. Select locations within the area of potential excavation for construction of an isolation/thermal barrier will then be core drilled to a depth 10 feet below the waste materials. Samples will be collected for analytical testing for radiological isotopes and geotechnical property characterization.

The soil core samples will be collected using sonic drilling technology. Samples for radiochemistry analyses will be collected using Auxier & Associates Procedure 3.3 (included in **Appendix A**). The soil samples will be taken at various depth locations of the core boring sample subject to where soil materials are encountered in each boring . Biased samples will be taken at locations of radioactivity as identified by field radiation detection instruments. Other samples will also be taken where no radiation is detected by such ra diation detection instruments.

4.2 LOCATION OF BOREHOLES

4.2.1 Phase 1B Investigation – Completion/Confirmation Investigation

As discussed above, soil borings, collection of core samples and submittal of laboratory samples are needed to further evaluate the report ed elevated gamma values obtained during the Phase 1 GCPT investigation. In order to verify whether the elevated gamma readings obtained during Phase 1 represent RIM, samples must be obtained and submitted for laboratory analyses for radium, thorium and uranium isotopes. It is not necessary to collect samples from all ten of the locations with elevated gamma readings to verify whether the elevated gamma readings reflect occurrences of RIM. Collection of soil cores and samples from five of the ten GCPT so undings with elevated gamma readings is considered sufficient to verify whether the elevated gamma readings correspond with occurrences of RIM. Therefore, drilling and collection of soil cores are proposed to be performed at or adjacent to the following locations:

- GCPT 5.3 – the GCPT sounding with the reported highest gamma reading
- GCPT 2.2 – a GCPT sounding with an intermediate level gamma reading
- GCPT 1.2 – the westernmost GCPT sounding with an elevated gamma reading
- WL-119 – a GCPT sounding with a slig htly elevated reading at 45.6 feet, in which analytical isotopes are needed to understand the elevated reading

- GCPT 8-1 – a GCPT sounding that had a slightly elevated reading at 29 feet, in which analytical isotopes are needed to understand the elevated reading

In addition, eight borings are proposed for the area where the GCPT soundings encountered refusal at shallow depths. The proposed locations and rationale are provided below:

- GCPT 12.5 – a southern location along path 12 to determine the elevation of the bedrock
- GCPT 13.3 – the northernmost location along line 13 where shallow refusal occurred
- GCPT 14.2 – the northernmost location along line 14 where shallow refusal occurred
- GCPT 14.4 – a location in the center portion of the area where shallow refusal occurred
- GCPT 14.7 – the southernmost location where shallow refusal occurred
- GCPT 15.2 – the only location along line 15 where shallow refusal occurred
- GCPT 16.3 – the northernmost location the potential isolation/thermal barrier alignment along Path 16
- GCPT 16.6 – a mid-path alignment check location of the bedrock elevation

After these borings are conducted and the bottom of waste is better understood, then it will be determined which GCPT soundings on the east side encountered refusal due to bedrock, and which GCPT soundings encountered obstructions. The GCPT locations that were deemed to be shallow due to obstructions will be reinvestigated within the Phase 2 investigation by either sonic drilling techniques, or a modified GCPT sounding method that would involve coring the first 10 feet of the GCPT sounding and backfilling the 10 feet initial hole with sand, then allowing the GCPT to scan the entire depth. This procedure will be discussed with the EPA prior to initialization.

4.2.2 Phase 1C Investigation – Delineation of the Extent of RIM

The eastern, northwestern, and southern extents of the elevated gamma occurrences in the southwestern portion of Area 1 can be delineated based on the results of the Phase 1 GCPT investigation and the results obtained during the RI investigation. Specifically, elevated downhole gamma readings were not encountered in GCPT soundings GCPT 6.2, 6.4, 6.5, and 7.2 located along the eastern margin of the area where elevated gamma readings were identified (Figure 2). Furthermore, neither elevated gamma readings nor radionuclide occurrences above those used to identify RIM were encountered in RI borings WL-107, WL-116 and WL-119 (McLaren Hart, 1996a and 1996b and EMSI, 2011). Therefore, the eastern extent of the area with elevated gamma readings has been defined (see Figure 2).

The northern extent of the area with elevated gamma readings (i.e., north of GCPT 3.1, 5.1, and 5.2) has not been defined. The occurrence of elevated gamma levels could extend from these borings to the north up to the area where RIM was previously identified as being present in the northwestern portion of Area 1 (e.g., in RI borings WL-105B, WL-102, WL-106B and NRC boring PVC-36) or the area of elevated gamma levels identified in the Phase 1 GCPT soundings may terminate before reaching the northern edge of the area previously identified as containing

RIM (see the redline boundary shown on Figure 2). Regardless of which of these conditions exist, additional characterization to the north of the existing Pha se 1 GCPT soundings is not needed for the isolation/thermal barrier evaluation, as the proposed location for the isolation/thermal barrier would be to the south of the area of the elevated gamma readings.

GCPT soundings 1.1 and 2.1 along with RI boring WL -124 define the northwestern extent of the area with elevated gamma readings. Downhole gamma logging of boring WL -124 did not detect elevated gamma readings or radionuclide activities above the unrestricted use levels; however, no soil was encountered in the waste materials in this area so the only sample obtained and submitted for laboratory analyses from this boring was obtained from the ground surface. Based on the combined results from the two GCPT soundings and the RI boring, additional drilling is no t needed to delineate the northwestern extent of elevated gamma readings.

The western extent of elevated gamma readings, to the west of GCPT boring 1.2, has not been defined; however, there is only approximately 25 ft of open ground between GCPT sounding 1.2 and the existing transfer station building. Therefore, only one additional boring could potentially be drilled in this area (subject to inspection of the area and utility clearance to determine actual suitability for additional drilling). The existing soil boring array also does not define the extent of elevated gamma readings to the south of boring GCPT 1.2, so an additional boring may also be required in this area.

The overall southern extent of the area of elevated gamma readings can be generally defined by GCPT soundings 3.2, 5.4 (still need to investigate background levels for 5.4) , 6.4 and 6.5 and RI borings WL -107, WL -121, WL -122 and WL -123 which did not detect elevated gamma readings or radionuclide activities above the unrestricted use levels (however, although elevated downhole gamma readings were not measured in borings WL -121, -122, and -123, soil was not encountered in the waste materials in these borings so the only samples obtained and submitted for laboratory analyses from these borings were collected from the ground surface). Significant separation does exist between some of the RI borings (e.g., between GCPT 4.2 and WL-122) so the exact limits of the elevated gamma readings in this area are not precisely known. Because this area may be represent a potential alignment for an isolation/thermal barrier, additional drilling in this area is recommended.

Tentative boring locations to further define the extent of the elevated gamma occurrences are provided on Figure 3. The exact number and location of additional soil borings to address this objective will be determined based on the results of the Phase 1B drilling, logging, and sampling activities in the area of the elevated gamma readings identified by the Phase 1 GCPT program.

4.2.3 Phase 2 Core Sampling Investigation

As previously discussed, additional data are required to determine an appropriate location and alignment for an isolation/thermal barrier. The specific alignment cannot be determined until evaluation of the Phase 1 GCPT investigati on results is completed and the Phase 1B and 1C

investigations have been performed. After completion of all Phase 1 investigations, a proposed alignment and conceptual design for an isolation/thermal barrier will be developed. Once the proposed alignment is determined, locations for Phase 2 borings can be identified. The specific number and locations of borings for the Phase 2 program will be determined based on the results of the Phase 1 GCPT, Phase 1B and Phase 1C investigations. It is anticipated tha t the proposed locations of t he Phase 2 boreholes will be distributed at regular intervals along the proposed alignment. An addendum to this work plan will be prepared to present the locations of the Phase 2 borings.

4.3 BORING TECHNIQUES

4.3.1 Sonic Drilling

The MDNR suggested a coring procedure such as sonic drilling within their August 20, 2013 , letter to the Bridgeton Landfill, LLC. Therefore, the sonic drilling technique will be used to advance the borings and collect core samples.

Sonic drilling conducted in accordance with ASTM D6914 will be used for the advancement of a continuous core for each borehole. ASTM D6914 provides guidance and discussion about this technique which is summarized in this section.

Sonic drilling is used for geo -environmental investigative programs. Sonic drilling offers the benefit of significantly reduced drill cuttings and reduced fluid production. Furthermore, sonic drilling does not entail the use of any drilling fluids such as air or water to circulate cuttings (water may be used to cool the downhole equipment) and therefore does not result in any form of emissions at the ground surface. The conti nuous core sample recovered by the sonic drilling technique provides a representative lithological column for review and analysis. The ability to cause vibration to the casing string eliminates the complication of backfill bridging common to other drilling methods and reduces the risk of casing lockup allowing for easy casing withdrawal during grouting.

The cutting action, as the sonic drilling bit passes through the formation, may cause disturbance to the soil structure along the borehole wall. The vibratory action of directing the sample into the sample barrel and then vibrating it back out can cause distortion of the specimen. Core samples will be hydraulically extracted from the sample barrel to reduce distortion. The use of split barrels, with or without liners, may improve the sample condition but may not completely remove the vibratory effect.

Some of the GCPT soundings were unable to be advanced due to large concrete construction and demolition debris fill encountered during the sounding. The sonic rig will be able to penetrate these fill materials. Sonic drilling through construction and demolition debris material may require the use of fluid (no air drilling allowed) to remove drill cuttings from the face of the bit, as they generally cannot be forced into the formation.

Some heat generation may occur within the borehole due to the use of sonic drilling. Liquid (potable water) will be injected down the drill string to reduce potential heat generation. Use of liquid will also increase core recovery. No liquid return to the top of the boring is anticipated.

4.3.2 Other Techniques

GCPT drilling may be used to further delineate the extent of elevated gamma readings in the southwestern portion of Area 1 (i.e., the Phase 1C investigation). A decision r egarding the potential applicability of further GCPT drilling will be made based on the results of the Phase 1B investigation and may include comparison of the relative merits of GCPT and sonic drilling techniques. If additional GCPT drilling is determine d to be suitable, the procedures for conducting such drilling will be the same as those used during the Phase 1 investigation as described in the prior Phase 1 work plan (FEI, 2013).

4.4 Site Preparations

The selected location for a given soil boring will be l ocated and marked by a land surveyor before sampling will begin at that location. These locations will be surveyed, horizontally and vertically, using the local Site coordinate system and recorded.

4.5 Equipment Preparation and Safety Training

Equipment will be in proper working order and inspected to determine if it meets safety requirements per Auxier & Associates Procedure 2.1 in **Appendix A**. Personnel will be briefed on potential hazards including working around moving equipment, physical hazards, biota, a nd risks associated with radiological or chemical exposures. Health and Safety Protocol/Procedures pertaining to general and radiological aspects of drilling in impacted areas are included in the HASP.

It is anticipated that all work will be completed in modified OSHA level D personal protective equipment (PPE), as required by the A uxier & Associates Radiation Safety Officer or his on -site designee (RSO). R espirators for protection from radionuclide exposure will not be routinely required but will be made available to workers. Respirators for protection from dust inhalation may be used if there are continuous plumes of visible dust from the borehole or soil cores ; however this condition is not anticipated to occur. Application of water during drilling sh ould alleviate this situation. A decision to require use of respirators may be made by the RSO if conditions are encountered that warrant use of respirators for protection from dust or radionuclides.

Survey instrumentation will be calibrated and documenta tion of calibration will be available for inspection. Sampling equipment and industrial hygiene monitoring equipment will be in proper working order and documentation of calibration (if applicable) will be available for inspection. A daily instrument res ponse check will be performed on all radiological instruments used for

quantitative measurements before the instruments are used. The results of these response checks will be recorded and retained for inspection.

4.6 SURFACE RADIATION MEASUREMENTS

Drill sites and access paths to drill sites will be surveyed by the RSO prior to entry or the start of any drilling activities. The RSO will conduct an overland gamma scan of the drill sites and access roads to the extent that such surveys were not previously perfor med in conjunction with the Phase 1 GCPT investigation. The same procedures used for the Phase 1 GCPT surveys will be used for any surveys performed in conjunction with the Phase 1B and 1C or Phase 2 work. These procedures were previously present ed in th e Phase 1 GCPT work plan (F EI, 2013); however, for completeness, the procedures to be used are included below.

For any areas without previous surface scans in the Phase 1 investigation, a Ludlum 2221 ratemeter/scaler mated to a Ludlum 44 -20 3x3" NaI detector (or equivalent equipment) will be used to survey selected portions of ground surface within and around Area 1. This instrument will be coupled to a Trimble GPS and operated in the ratemeter mode. This mode will allow the gamma count rate from t he instrument to be collected at one -second intervals and assigned to its specific measurement location (latitude and longitude). The operator will hold the detector approximately 30 cm above the ground surface and advance across the areas of interest in a series of straight lines at a rate of approximately one meter per second. The separation distance between the lines will be approximately 1.5 meters. After the survey, the field data will be processed using a combination of industry standard commercial computer applications. Because all data points will be tied to a spatial coordinate, a map of the data will identify areas of surface soil containing RIM. These areas can then be located in the field and avoided or covered. If the overland gamma scan i ndicates a radiological level over background, the RSO will notify the clearing crew that they could be in an area that has surface RIM and to proceed in a manner that avoids ground disturbance. The path to each borehole location will be cleared of vegeta tion 10 -20 feet wide in the general direction dictated by the onsite surveyor . The cleared path and the path to be cleared (as much as practicable) will be scanned with the overland gamma scanning equipment; then the next section will be cleared. This pro cedure will be used in the same sequence until the desired borehole location has been reached. It is envisioned that paths to each borehole location will be approximately 10-15 feet wide, while a larger area (25-30 feet diameter) will be cleared at each borehole location.

Exposure and dose rates will be measured over each borehole location before drilling starts. In addition, thermoluminesent dosimeters (TLD s) or equivalent will be installed 1 -meter above a minimum of three (3) marked boreholes. These TLDs will be collected after 10 weeks or before isolation/thermal barrier installation, whichever is sooner, and sent to the vendor for processing. These measurements will be used to document exposure rates within Area 1.

4.7 BOREHOLE SAMPLING

The investigation activities will be conducted using sampling technology associated with the sonic drilling technique (ASTM D6914). The Sonic drilling crew will proceed to each marked borehole location and continuous soil cores will be collected and logged.

At each boring location, soil cores will be advanced through any overburden and into the underlying landfill deposits, terminating in the underlying unconsolidated material. If refusal is met, the borehole location may be off-set at the discretion of the Project Manager. It is anticipated that the total depth of each borehole will be approximately 30 to 60 feet bgs but may extend as far as 80 feet bgs in places. Soil cores from these boreholes will be labeled with a unique sample identification number that will include a reference to the boring designation from the sampling map, the borehole number (if more than one borehole is taken at the same location), the core sequence number or depth interval, an arrow indicating the top of the soil core, and the date.

Soil cores obtained from each borehole will be examined by the project geologist/field engineer. At a minimum, the geologist/field engineer will identify the depths that soil transitions from one subsurface unit to the next and identify any stratum that may affect the installation or efficacy of the isolation/thermal barrier. The entire soil core from the borehole will be stored in sealed PVC pipes.

4.8 SUBSURFACE MEASUREMENTS

An integrated procedure using vertical scanning of the borehole (borehole gamma logging) and gamma scanning of the produced soil core will be used to identify subsurface gamma anomalies and match soil samples with those anomalies. Borehole logging will be used to assess whether measureable amounts of elevated subsurface gamma radiation exist in the borehole, and to determine the depth and thickness of any subsurface anomalies. Soil core gamma logging will be used to locate any soils in the sample tube that may produce elevated levels of gamma radiation. This integrated approach will allow samplers to identify the depth(s) of potentially impacted soils (indicated by the downhole gamma logs) even if the soil column in the sampling tube is displaced to a different depth in the tube during sampling.

4.8.1 Borehole Gamma Logging

Once the borehole has reached its total depth, a 2 ½ inch minimum solid PVC pipe with a bottom cap will be inserted into the hole. The boring diameter should be approximately 6 inches, so an annular space will exist. This annular space will be backfilled with sand from the surface once the borehole gamma logging has concluded. A bentonite seal will be used in the upper 5 feet of backfill. The PVC pipe will extend 4 feet above the surface, and a PVC endcap will be secured to the finished PVC pipe before the borehole has been completed.

A 1-inch NaI gamma probe with a long cable will be lowered into the sleeve and used to record one (1) minute radiation measurements at 6 -inch intervals along the length of each borehole. These measurements will be recorded in counts per minute (cpm) and the depth of each measurement will be recorded as depth bgs in negative feet. For example, the depth of a gamma measurement taken at 3.5 feet bgs will be recorded as " -3.5 feet". This "g amma log" will be used to identify the depth bgs of any subsurface soil layers producing eleva ted radioactivity. A modified borehole logging procedure excerpted from the Auxier & Associates procedure manual is provided in **Appendix A**.

4.8.2 Soil Core Gamma Scanning

Concurrently with borehole gamma logging, any radioactivity associated with the soil core will be determined by taking 1 -minute integrated gamma measurements at 1 -foot intervals using a 3x3 inch NaI gamma detector along the length of the core(s) that contains the upper strata of fill and refuse material. After all measurements have been taken along the soil core tube, samples for laboratory analysis will be collected from those core intervals producing anomalous results. For the purpose of this work plan, anomalous areas are those intervals of soil producing a gamma response that is 30% greater than the median of all gamma responses observed for the same borehole. This 30% criterion, referred to as the Elevated Measurement Location (EML) criterion, is adapted from New Jersey's Field Sampling Procedure Manual dated 12.7.10. The procedure from this manual was selected because it provides a citable procedure developed by a reputable third party (N ew Jersey Department of Environmental Protection's Bureau of Radiation.)

4.8.3 Geological Examination of Soil Core

The project geologist/field engineer will review the core samples and log the boring based upon the cores and the corresponding depths. A geologic log for each boring will be developed.

4.9 SOIL SAMPLING

Soil samples will be collected based upon the results of the borehole gamma logging, soil core gamma scanning, and geological evaluation of the contents of the soil core . At a minimum, all anomalous intervals of the soil column identified in Section 4.8 will be sampled. Additional intervals of interest may be selected for discretionary sampling by the project geologist/engineer or RSO. At a minimum two (2) soil samples will be collected from each boring.

When sampling, the associated 1 -foot interval of soil collected will be identified in the field notes for that tube and the sample associated with that interval will be sent for analysis at the analytical labor atory. The depth of the sample will be determined by measuring from the ground surface.

The volume of soil sample, type of sample container, and preservation requirements are provided on Table 1. Soil samples will be analyzed for isotopic Uranium, isot opic Thorium, and gamma spectroscopy at the Eberline Services Oak Ridge Laboratory located in Oak Ridge, TN using the methods listed in Table 1. Method Detection Activities (MDAs) for these methods are also indicated on Table 1.

Field duplicate samples wi ll be collected at a frequency of one duplicate for every 10 investigative samples or one field duplicate sample per sampling event if less than 10 investigative samples are collected.

Table 1 - Analytical Methods and Sample Requirements

MATRIX	CONTAINER	PRESERVATIVE	ANALYTE	VOLUME OR MASS REQUIRED	METHOD REFERENCE	MDA [a]
Soil	0.5 liter large-mouth Nalgene jar or plastic ziplock bag	None	Isotopic Uranium	< 10 g	EML U-02 Modified	<1.0 pCi/g [b, c]
			Isotopic Thorium	< 10 g	EML Th-01 Modified	<1.0 pCi/g [c]
			Gamma emitters including: Bi-214 & Pb-214 (Ra-226) Ac-228 (Ra-228), and K-40	400-500 grams	LANL ER-130 Modified	<1.0 pCi/g [c]
Water	1 Gallon Cubitainer	pH <2.0 HNO_3	Gross Alpha & Beta	Two gallons in 1-Gal Cubitainers	EPA 900.0 Modified or EPA 900.1 Modified [d]	<5 pCi/L
			Isotopic Thorium		EML Th-01 Modified	<1.0 pCi/L
			Radium-226		EPA 903.0 Modified	<1.0 pCi/L
			Radium-228		EPA 904.0 Modified	<2.0 pCi/L
Air	47mm Filter	None	Gross Alpha & Beta	Air volume sampled ≥ 1 x 10^8 mL	EPA 900.0 Modified	<5x10^{-14} µCi/mL [e, f]
			Isotopic Thorium		EML Th-01 Modified	<5x10^{-14} µCi/mL [e, f]

[a] MDA = method detection activity

[b] pCi = picoCuries

[c] Standard MDA. Lower MDA's available.

[d] Dependent on dissolved solids content.

[e] uCi = microCuries

[f] Dependent on volume of air sampled.

4.10 SAMPLE HANDLING AND SHIPPING

Each sample will be placed in the sample container indicated on Table 1 and sealed. A sample label will be placed on the outside of the container. The sample label will include the unique sample identifier discussed below, client name, project location, analyses to be performed, any preservative included with the sample, the collection date and time, and the name of the person who collected the sample.

To be consistent with the system used in previous sampling campaigns, unique sample identifiers will consist of an alpha -numeric code including the area label, the borehole identifier, the sample type and matrix, followed by the sample depth. The numeric portion of the sample identifier describing the depth will be separated from the borehole information by a dash "-". The starting and ending depths will be separated by a dash. The identifiers expected for this sampling program are listed below:

- Area label: Area 1 (A1)
- Borehole ID: A four digit descriptor of the borehole location, such as 12-03 for the third borehole along corridor 12 or equivalent. Note the 2-digit number designating numerical order along the corridor (01, 02, … 10, etc.). This is desirable when sorting results for presentation.
- Sample Type and Matrix: IS (investigation soil)
- Sample Depth: This will consist of start and stop sample depths in feet with a dash between the two depths, such as 00.0-00.5 (0-6 inches). Note – grab samples of soil will have only one depth value associated with them (00.0-00.0).

For example, a soil sample collected in Area 1 (A1) along Pa th 4 (04) from the third borehole (03) for investigative purposes (IS) across a depth interval of 1 to 2 feet would be labeled:

A10403IS 01.0-02.0.

The sample containers will be stored in a secure location in a manner that maintains chain -of-custody requirements until such time as they are ready for shipment. If samples are selected for laboratory analysis, they will be logged on a chain-of-custody form and placed in a cooler.

A chain-of-custody form will accompany every shipment of samples to the analytical laboratory. The purpose of the chain -of-custody form is to establish the documentation necessary to trace possession from the time of collection to final disposal, and to identify the type of analysis requested. Any correction to the chain -of-custody record will be marked out with a single line, initialed and dated using black indelible ink by the person making the correction. Each chain-of-custody form will include signatures of the appropriate indi viduals indicated on the form. Shipping to the analytical laboratory will be via common courier directly to the laboratory.

The chain-of-custody form for that shipment will be placed in the cooler until the cooler is shipped. Prior to sealing the cooler, the cooler will be surveyed with a Ludlum Model 19 portable gamma radiation detector or equivalent and the maximum reading will be recorded on the chain-of-custody form. The original chain-of-custody form will be placed in the cooler and a copy retained at the Site. The cooler will be completely and securely sealed prior to shipment and a custody seal will be adhered on a side of the cooler from the lid to the body of the cooler. The seal will be signed and dated and clear packing tape placed over the seal. All samples will be packaged and shipped to the laboratory in accordance with USDOT regulations (see Auxier & Associates Procedure 3.8 "Sample Chain of Custody" in **Appendix A**).

4.11 Sample Processing and Analysis

Samples will be sent to Eberline Services Oak Ridge Laboratory for analysis. The samples will be received at the laboratory by the sample custodian. The custody-sealed coolers containing the samples will be opened and the contents inspected against the chain-of-custody form. Chain-of custody forms will be reviewed for completeness, and samples will be logged and assigned a unique laboratory sample number. Any discrepancies or abnormalities in samples will be noted by the laboratory and the Project Manager will be promptly notified.

All samples will be weighed prior to drying. After samples are dry, the samples will be reweighed and then ground to promote homogeneity. Results of the sample analyses are not expected to be received for four to six weeks from the time the samples are received by Eberline Services.

Investigative and field duplicate samples will be analyzed for the parameters using the methods listed on Table 1. Laboratory quality control (QC) samples will be prepared at the laboratory and analyzed along with the field samples to monitor the accuracy and precision of analysis. Quality Control and Quality Assurance internal to the Eberline Services Oak Ridge Laboratory; performance and system audits; control and maintenance of measurement and test equipment; data reduction, verification, reporting, and management; document control; and corrective action are included in the Oak Ridge Laboratory Quality Assurance Program Manual (Eberline, 2013), which is provided with this Work Plan as **Appendix B**. The Eberline Oak Ridge Laboratory successfully participates in annual Mixed Analyte Performance Evaluation Program (MAPEP) performance testing such as that conducted by the Department of Energy.

5 HEALTH AND SAFETY MONITORING

Procedures to support and monitor worker health and safety will be implemented in conjunction with any work performed at the Site. It is expected that the same procedures that were used during the Phase 1 GCPT investigation will also be used during Phases 1B, 1C and 2 work, with the exception that additional air monitoring activities will be conducted during the Phases 1B, 1C, and 2 programs. Additional details are contained in the HASP. A description of the particulate air monitoring activities is provided below.

In addition to the use of personal air monitoring pumps (see HASP), monitoring of possible radionuclide occurrences in airborne particulates will also be performed using fixed location air monitoring pumps and filters. Use of fixed location air monitoring pumps and filters allows for use of larger pumps which can sample a larger air volume than can be achieved using the more portable personal air monitoring pumps. This results in a larger particulate sample which generally produces a lower detection limit than the other methods used on this project.

Fixed location air monitoring will be performed using RADeCO H809 -C air samplers (or equivalent) with 47 millimeter filters. These samplers include a two stage turbine blower capable of sampling a t rates of 1 to 5 cubic feet per minute (30 to 140 liters per minute). The advantage of using these types of samplers is that they are light weight and can be operated using battery power and therefore can be easily located and re -located to meet the spec ific monitoring needs of the various investigative activities.

Fixed location air monitoring will be conducted at two locations during performance of the work including adjacent to the field trailer located along the south side of Area 1 and adjacent to th e Bridgeton Landfill transfer station located to the west of Area 1. In addition, fixed location air monitoring will be performed at a third location along the downwind side of the boundary of the specific work area. The down -wind boundary placement will generally provide a worst -case indication of concentrations in air adjacent to the investigative activity being monitored. The location of this third monitoring station will vary depending on the specific investigative activities being conducted each day.

The primary purpose of the fixed location air monitors is to collect data to assess worker doses. They are therefore operated primarily during the investigative activities, anticipated to occur over a period of 60 to 80 hours per week. Filters will be collected weekly (or every other week if necessary to obtain sufficient sample volume to support low minimum detectable activity levels – see additional discussion below) and counted on-site using a Ludlum Model 2929 with a 43-10-1 alpha/beta detector for screening/operational monitoring purposes in accordance with the requirements set forth in the HASP.

Filters from the fixed location air monitoring stations will also be sent to the Eberline Services Oak Ridge, TN laboratory for analysis using low -background counters. The results will be used to report worker dosimetry for each phase of the investigation. Results will be compared to derived air concentrations of radionuclides for occupation al exposure established by the Nuclear Regulatory Commission (NRC) [10 CFR Part 20, Appendix B, Table 1].

Pursuant to a request from EPA, the filters will also be analyzed for specific radioisotopes and the results will be compared to the effluent concentrations for air established by the NRC (10 CFR Part 20, Appendix B, Table 2) for assessment and control of dose to the public.

Using the mix of radionuclides published in the Baseline Risk Assessment (Auxier, 2000), 70% of the dose from any exposure to dust will be from particles containing the alpha emitter Thorium-230. The average annual release limit for Thorium -230 in effluent air is $3x10^{-14}$ microcuries per milliliter (µCi/m l) [NRC in 10 CFR 20, Appendix B, Table 2; Note: occupational standards are listed in Table 1 of this NRC Appendix B]. Assuming all of the alpha emissions are from Th orium-230, then the minimum detectable concentration (MDC) required to determine compliance with the Thorium-230 effluent limit will be less than $3x10^{-14}$ µCi/ml. The expected MDC for a one week sample will be on the order of 1 to $2x10^{-14}$ µC/ml for a 45 hour sample. Extending the sample duration to two weeks will reliably produce a minimum detectable concentration for gross alpha of $1x10^{-14}$ µCi/ml.

6 PROJECT TEAM

This Work Plan was prepared at the request of Bridgeton Landfill, LLC by Auxier & Associates, Inc. (A&A), a wholly owned subsidiary of USA Environment, LP , Feezor Engineering, Inc. (F EI), and Engineering Management Support, Inc. (EMSI). Roles and responsibilities of these project team members as well as subcontractors are as follows.

6.1 BRIDGETON LANDFILL, LLC

Bridgeton Landfill, LLC will retain overall management for the project and will retain Feezor Engineering, Inc,. Auxier & Associates , Engineering Management Support, Inc. and other necessary subcontractors to provide ser vices necessary to identify a proposed alignment and develop design information for an isolation/thermal barrier.

6.2 FEEZOR ENGINEERING, INC.

Feezor Engineering, Inc. (FEI) is the Project Manager selected to manage the investigation and coordinate required op erations on and off the site. FEI will supply GPS coordinates for the selected sampling locations. FEI will verify that all geospatial data are correct and fully documented. FEI will determine that:

- Actual sample locations correspond to specified coordinates;
- Elevation and depth bgs data are available for all actual sample locations, and
- Coordinates, elevations and depths of any relocated sample locations are captured and documented.

FEI will supply a geologist /field engineer to accompany the field team and examine the soil cores. The geologist /field engineer will receive the cores from the driller, label them, and prepare geologic/engineering descriptions of the soil cores as they are p roduced by the drillers. FEI will provide maps and drawings using data collected. FEI will also develop the final report summarizing the findings of the Phase 1B, 1C, and 2 investigations.

6.3 AUXIER & ASSOCIATES, INC.

A&A personnel have responsibility for all radiological measurements described in this plan and collecting, packaging, and shipping samples to the analytical laboratory . A&A will collate , validate, manage, and analyze the radiological data produced by this sampling program and prepare and submit a report summarizing the results.

A&A will supply the RSO and Radiation Control Technician (RCT) [see RCT roles and responsibilities in Section 7] , to be determined, who will manage and perform the radiological measurements and sampling described in this work plan and the HASP. Mr. Mike Bollenbacher, CHP of A&A will provide technical oversight on the radiological aspects of the field sampling and analytical activities.

6.4 Engineering Management Support, Inc.

Engineering Management Support, Inc. (EMSI) is responsible for investigation and evalu ation of potential remedial alternatives for Operable Unit 1. EMSI will provide oversight of the isolation/thermal barrier investigation and technical consultation relative to occurrences of RIM in Area 1, the proposed investigative and health and safety monitoring activities, and evaluation of the results of the field and laboratory investigations. Because EMSI is responsible for OU -1 work, and the isolation/thermal barrier investigation is being performed under the Administrative Order on Consent (AOC) for OU-1, EMSI will also provide coordination between the investigative team and EPA and perform reporting required under the AOC.

6.5 Drilling Subcontractor

Frontz Drilling will be the drilling subcontractor for the sonic drilling activities. The drilling subcontractor will provide for soil sampling by installing minimum 2.5 inch diameter boreholes at surveyed and marked locations. The drilling subcontractor will insert plastic sleeves in the borehole after cores have been extracted to allow for downhole gam ma logging of the boreholes. Frontz Drilling will supply all materials necessary to collect soil cores from those boreholes including direct push equipment capable of advancing b oreholes to depths of up to 100 feet, flexible or rigid liners and end caps, borehole inserts , and any necessary support vehicles and portable work tables.

Any additional GCPT drilling that may be conducted in conjunction with Phase 1C will be performed by ConeTec, the drilling subcontractor that performed the Phase 1 GCPT work.

6.6 Surveying Contractor

Weaver Boos will provide land surveying as necessary to support task completion. Specifically, the proposed and actual locations of the borings will, to the extent that they do not coincide with previously surveyed drilling locations , be surveyed prior to and/or upon completion of borehole drilling activities.

6.7 Analytical Laboratory

Eberline Services Oak Ridge Laboratory located in Oak Ridge, Tennessee (Eberline) will perform laboratory analyses of the soil/waste samples collected from the boreholes. Eberline will also analyze particulate samples obtained in conjunction with the air monitoring activities. Eberline is one of the nation's largest radiochemistry laboratory networks and offers comprehensive radiochemical analyses includin g environmental radiochemistry. Eberline holds numerous laboratory certifications, accreditations, and approvals; including National Environmental Laboratory Accreditation Program (NELAP) and Department of Energy Consolidated Accreditation Program (DOECAP). Eberline has previously and continues to provide radiochemistry analytical services in support of OU-1 monitoring activities at the Site.

7 CONTAMINATION SURVEYS AND DECONTAMINATION PROCEDURES

The potential to spread contamination will be mitigated by establishing readily identifiable areas around activities having the potential to encounter radiological materials. Access to these areas, called "Permitted Areas" in this work plan, will be controlled and limited to properly trained individuals who have read, understood, and signed the daily Radiation Work Permit governing activities in an area or areas. Equipment and personnel leaving these Permitted Areas will be surveyed as described below. If contamination is identified, the contamination will be removed and the equipment rechecked. This is an iterative process that will continue until equipment and personnel meet exit criteria.

7.1.1 Radiological Surveys

Surveys will be used to monitor and control exposures and the potential spread of contamination. The following subsections describe the surveys to be used and their requirements.

7.1.1.1 Baseline Entry Survey – Equipment

All vehicles and large equipment entering Area 1 will be surveyed by the Radiation Control Technician (RCT) for fixed alpha and beta contamination before their initial entrance into Area 1. The survey will be conducted using a Ludlum Model 2360 scaler/ratemeter with a Model 43-93 alpha/beta detector probe (or equivalent), as described in A&A Procedure 2.7 (**Appendix A**).

7.1.1.2 Permitted Area Exit Survey - Personnel

Personnel exiting a Permitted Area will have their shoes and clothing scanned upon leaving the area, as described in A&A Procedure 2.7. The name of the individual, the results of the exit survey, the location, and the times they entered and left the area will be recorded on a standard form such as A&A Form 11 (Personnel Monitoring Form) or a log sheet attached to a copy of the Radiation Work Permit. A reading of two (2) times the ambient background level will require decontamination before leaving the area.

7.1.1.3 Permitted Area Exit Survey - Equipment

Heavy equipment working inside a Permitted Area will be surveyed by the RCT before leaving the area. All surfaces in contact with soil will be scanned for alpha, beta and gamma surface activity with a Ludlum Model 12 survey meter coupled to a Model 44-9 alpha/beta/gamma pancake detector (or equivalent) as described in A&A Procedure 2.7. A reading of two (2) times the ambient background level will require the equipment to be decontaminated and resurveyed before it leaves the Permitted Area.

Sections of the downhole drilling equipment will be sampled with a swipe between sampling locations to detect any removable activity on the surface of the tool string. The swipe samples will be screened in the field with a Ludlum Model 12 survey meter coupled to a Model 43-5 alpha detector, or equivalent. A final measurement of alpha and beta activity on the smear will

be performed using a Ludlum Model 2929 scaler coupled to a Ludlum Model 43-10-1 alpha/beta counter or a low-background alpha/beta counter such as an XLB-5.

7.1.1.4 Final Release Survey - Equipment

Equipment working inside a Permitted Area and equipment that might inadvertently contact contaminated soil outside a cleared easement will be surveyed by the RCT before leaving Area 1. All surfaces in contact with soil will be scanned for alpha and beta contamination with a Ludlum Model 2360 scaler/ratemeter coupled with a Model 43-93 probe (or equivalent) as described in A&A Procedure 2.7.

Removable contamination will be sampled by swiping 100 cm^2 areas on parts of the equipment that were in contact with soil surfaces as described in A&A Procedure 3.6. These smear samples will be counted with a Ludlum Model 2929 scaler coupled to a Ludlum 43-10-1 detector.

If contamination is found, the vehicle will be decontaminated until it meets final release standards listed in Table 2. The equipment identification and the final results will be recorded on the appropriate equipment release form from the A&A Procedures Manual and the equipment will be unconditionally released from Area 1.

Table 2 - Final Release Survey Limits for Equipment

Parameter	Acceptable Surface Contamination Levels [a]	Equivalent Meter Response in the Field [b]
Fixed Alpha (Ra-226 & Th-230)	100 dpm/100cm^2, average 300 dpm/100cm^2, maximum	20 cpm Mo 2360/Mo 43-93 60 cpm Mo 2360/Mo 43-93
Fixed Beta (U_{nat} & assoc. decay products)	5,000 dpm/100cm^2, average 15,000 dpm/100cm^2, maximum	750 cpm Mo 2360/Mo 43-93 2250 cpm Mo 2360/Mo 43-93
Removable Alpha	20 dpm/100cm^2, average	Na
Removable Beta	1,000 dpm/100cm^2, average	Na

[a] From U.S. Atomic Energy Commission's RegGuide 1.86 "*Termination of Operating Licenses for Nuclear Reactors*," Table 1 Acceptable Surface Contamination Levels.

[b] Nominal values based on default efficiencies published by Ludlum Instruments on their web site (20% α, 15% β). Meter efficiencies may be reevaluated at the site.

7.1.2 Equipment Decontamination

All equipment (including but not limited to the drill rig) will be surveyed. If radioactive contamination is detected, the equipment will be decontaminated. A phased approach to decontamination will be employed to minimize the generation of solid waste and waste water.

7.1.2.1 Dry Decontamination

It is expected that any contamination will be associated with loose, removable dirt and mud that may attach to equipment surfaces during operations. If contamination is detected on equipment after operations are completed in a boring location, the equipment will be

decontaminated before moving to the next boring location. Visual patches of dirt and mud will be removed from the contaminated surfaces of the equipment using damp wipes, brushes, and scrapers. Used decontamination supplies will be placed in marked containers or bags. The remainder of material removed during dry decontamination will be placed in a separate container with hard plastic or metal sides and staged for retrieval and sampling. Any solid radioactive waste generated will be packaged and characterized for handling as discussed in Section 7.1.2.3 .

7.1.2.2 Wet Decontamination of Equipment

If dry decontamination is not sufficient to meet release levels, the equipment will be moved to the radiological decontamination pad. Contaminated surfaces will be scrubbed with brushes and soapy water until they are visually clean. The equipment will be surveyed again for both alpha and beta surface activity. If fixed or removable ac tivity exceeding the release limits is found, the contaminated surface will be decontaminated using more aggressive methods such as pressure washing or abrasive blasting until the release criteria are met.

7.1.2.3 Waste/Water Management

Water used to decontaminate equipment will be placed in marked holding tanks and/or drums, sampled, and packaged and shipped to a licensed, managed disposal site. The volume of sample required, sample container type, and preservative requirements for any water sample(s) are provide d on Table 1. Decontamination water samples will be analyzed for gross alpha and beta and isotopic Uranium. If the gross alpha results are greater than 15 pCi/L, then the sample(s) will be analyzed further for Radium -226 and isotopic Thorium. Analytical methods and MDAs are included on Table 1.

Any solid radioactive waste generated will be packaged and characterized for shipping. This material will be shipped to a managed disposal/treatment facilit y that is permitted to receive the waste.

7.1.2.4 Final Housekeeping Wash-down

Any equipment released from Area 1 will be washed with water to remove visible dirt from its surfaces prior to its removal from the project. This final housekeeping can be performed in an uncontrolled area and any water generated from this final cleaning of previously released equipment will be considered unimpacted.

7.1.3 Decontamination Pads

Two separate decontamination pads were constructed during the Phase 1 GCPT investigation . A radiological decontamination pad was constructed near PVC -38. This pad will be used to decontaminate equipment failing the free -release radiological requirements and was constructed to contain solid waste and decontamination water.

A second pad was also constructed for general cleaning of equipment that has not been exposed to RIM materials. This gravel surface pad is located adjacent to the fence near the entrance road to Area 1.

8 QUALITY ASSURANCE

The various activities and requirements to be implemented to su pport collection of data of the quality necessary to support decision making for the isolation/thermal barrier investigation and design are presented in this work plan. This section provides an overview of the specific data quality objectives for the anal ytical laboratory data. A listing of where the various requirements of a quality assurance project plan (QAPP) are located in this work plan is also included. In addition, the specific data validation procedures to be employed to assess the quality of the data provided by the analytical laboratory are presented in this section.

8.1 ANALYTICAL DATA QUALITY OBJECTIVES

Samples of waste/soil material will be obtained and submitted to Eberline for determination of radionuclide activity levels. As discussed in Sec tion 1.1.1 of this work plan, RIM is defined as materials that contain any of the following:

- Combined radium-226 and radium-228 at levels greater than 5 pCi/g above background (e.g., 7.9 pCi/g);
- Combined thorium -230 and thorium -232 at levels greater than 5 pCi/g above background (e.g., 7.9 pCi/g); and
- Total uranium greater than 50 pCi/g plus background (e.g. 54.5 pCi/g) [EMSI, 2011].

The MDA levels for analytical methods listed on Table 1 should provide data of sufficient quality to allow for characterizat ion of the waste/soil samples necessary to identify any occurrences of RIM in the areas being considered for construction of an isolation/thermal barrier.

Analytical data will also be developed to assess worker doses and verify that particulate concentrations of radionuclides in air do not pose a risk to the general public. Specifically, the particulate filter samples will be submitted to Eberline for analysis of thorium -230. As discussed in Section 6 of this work plan, the effluent limit for airborne tho rium-230 established by the N RC (10 CFR Part 20 Appendix B, Table 2) is $3x10^{-14}$ µCi/ml. Therefore, the minimum detectable concentration (MDC) required from the analytical laboratory to determine compliance with the thorium-230 effluent limit will be less than $3x10^{-14}$ µCi/ml. Assuming that all of the alpha emissions result from decay of thorium -230, the MDC for gross alpha in a sample containing 1.8 x 108 mL (60 liters per minute for 50 hours) will be $2.8x10^{-14}$ µCi/ml. Extending the sample duration to tw o full weeks (100 to 120 hours) will produce a sample volume of approximately 3.6×10^{8} or more, and result in minimum detectable concentrations for gross alpha and thorium-230 of 1 to 2 x 10^{-14} µCi/ml. Therefore, the proposed sampling and analyses should provide data of sufficient quality to evaluate potential particulate occurrences of radionuclides in air.

8.2 QUALITY ASSURANCE PROJECT PLAN REQUIREMENTS

EPA has established guidance relative to the requirements for Quality Assurance Project Plans (EPA, 2002). A listing of the QAPP requirements and the location in this work plan where these requirements are addressed (if and as appropriate for the scope of the investigations) are presented on Table 3.

8.3 DATA VALIDATION

The data validation process will consist of evaluation of the results of individual samples collected and analyzed to determine if results are within acceptable limits. These quantitative or q ualitative limits of acceptability are defined for Precision, Accuracy, Representativeness, Comparability, and Completeness (PARCC), as discussed below.

Precision: Precision is defined as the agreement between a set of replicate measurements without assum ption or knowledge of the true value. Agreement is expressed as either the Relative Percent Difference (RPD) for duplicate measurements, or the range and standard deviation for larger numbers of replicates. Data regarding precision are obtained by analyz ing duplicate or replicate samples.

Accuracy: Accuracy is a measure of the closeness of a sample analysis result to the "true" value. Accuracy of sample analyses is evaluated using laboratory control samples that are prepared and analyzed by the analytic al laboratory as part of the analyses of the various batches (lots) of samples.

Representativeness: Representativeness is the degree to which data accurately and precisely represent characteristics of a population, parameter variations at a sampling poin t, or an environmental condition. For this investigation, representativeness will be ensured by the selection of sampling locations in accordance with the goals of the sampling design requirements presented in Section 1.2.

Comparability: Data are comparable if collection techniques, measurement procedures, methods, and reporting units are equivalent for the samples within a sample set. These criteria allow comparison of data from different sources. Comparable data will be obtained by specifying standard units for physical measurements and standard procedures for sample collection, processing, and analysis.

Completeness: Data are considered complete when a prescribed percentage of the total intended measurements and samples are obtained . Analytical completeness is defined as the percentage of valid analytical results requested. For this investigation, collection of samples at a minimum of 80% percent of the planned sampling locations must be obtained to achieve a satisfactory level of data completeness.

Level III data validation will be performed consisting of manually examining data deliverables to determine data quality for the analytical results for field investigative and duplicate samples. Radionuclide data will be validated in general accordance with the guidelines and criteria specified in the MARLAP Manual (EPA, 2004). Data validation will include application of appropriate data qualifiers to the analytical results based on adherence to method protocols and project-specific QA/QC limits.

The following elements will be reviewed for compliance as part of the data validation:

- Methodology;
- Holding Times;
- Calibration;
- Blanks;
- Spikes;
- Duplicates;
- LCSs;
- Practical Quantitation Limits;
- Analyte Identification; and
- Analyte Quantification.

During the subsequent data evaluation process, the sampling, analysis, and data collection documentation will also be reviewed for completeness and consistency with data quality objectives. Data validation reports will be reviewed to identify any limitations associated with the analytical data.

Table 3 – Crosswalk Between Quality Assurance Project Plan Requirements & Workplan Sections

Element No.	Element Description	Work Plan Page/Section	Comments
A1	Title and Approval Sheet	Page i	Note approval of the work plan will be separately provided by letter or e-mail from EPA
A2	Table of Contents	Page ii	
A3	Distribution List	Transmittal letter	
A4	Project/Task Organization	Sections 1.2 and 10	
A5	Problem Definition and Background	Section 1.1	
A6	Project/Task Description	Section 1.2	
A7	Quality Objectives and Criteria	Section 8.1	
A8	Special Training/Certifications	Not applicable	
A9	Documentation and Records	Section 9	
B1	Sampling Process Design	Section 4	
B2	Sampling Methods	Section 4	
B3	Sample Handling and Custody	Section 4.10	
B4	Analytical Methods	Table 1	
B5	Quality Control	Section 4.9	
B6	Instrumentation/Equipment Testing, Inspection, and Maintenance	Health and Safety Plan	
B7	Instrument/Equipment Calibration and Frequency	Health and Safety Plan	
B8	Inspection/Acceptance of Supplies and Consumables	Not applicable	
B9	Non-direct Measurements	Section 4.8	
B10	Data Management	Section 9	
C1	Assessments and Response Actions	Not applicable	Work will be completed prior to receipt of analytical results. Any data quality issues identified during data validation will be addressed directly with the laboratory. Sample holding times are sufficiently long to all for re-analysis/additional analyses will be performed to meet project objectives if necessary.
C2	Reports to Management	Section 9	
D1	Data Review, Verification and Validation	Section 8.3	
D2	Verification and Validation Methods	Section 8.3	
D3	Reconciliation with User Requirements	Section 8.3	

9 REPORTING

Field investigation activities and the findings from these efforts will be summarized in a stand - alone Subsurface Investigation Summary Report.

The field data (boring logs, soil screening data, survey data, etc.) will be recorded daily on paper forms and log books. These paper records will be maintained in a managed repository such as an office or a climate controlled storage facility for future reference.

Analytical results will be sent in electronic format from the laboratory to Auxier & Associates. Laboratory analytical data will be recorded digitally and maintained in a relational database. Full Level III laboratory reports containing documentation of the analytical process, QA /QC data and analytical instrument performance will be sent in electronic or paper format from the laboratories to Auxier & Associates and EMSI. These analytical reports will include:

- Copies of completed chain of custody forms,
- Instrument calibration and/or instrument quality control records,
- Results for blanks and spikes associated with the reported results,
- Results for duplicates,
- Sufficient documentation to reproduce calculated results from instrument responses, and
- A case narrative describing the analytical process used to produce the published results.

All of the laboratory data will be validated by examining the test results. The laboratory reports and validation packets will be maintained at Auxier & Associates.

Information regarding the progress of the field work and sampling activities will be provided in the monthly progress reports for West lake Landfill Operable Unit 1 (OU -1) prepared by EMSI. Analytical reports will also be provided by EMSI as they are received in conjunction with submittal of the monthly progress reports for OU-1.

FEI will author a final report summarizing:

- Field preparations;
- Boring locations and sample locations;
- Lithology logs;
- Analytical testing and validation results; and
- A discussion on the feasibility of the isolation/thermal barrier alignment.

10 ANTICIPATED PROJECT SCHEDULE

An anticipated project schedule tasks are provided below. Significant factors affect ing the overall project schedule including drill rig availability, weather conditions, time required to perform laboratory analyses to achieve the minimum detectable activity levels required to meet the project data quality objectives, time required to validate the laboratory analytical data, time required to review the results of the field and laboratory data an d finalize the scope of work and specific sampling requirements for the subsequent phase of work. Laboratory reports are expected to be received four to six weeks after submission of samples . Data validation is anticipated to require two to four weeks an d is dependent upon the validator's schedule at the time the analytical reports are made available. The investigation summary report is anticipated to be complete and ready for submittal to the EPA one month after the analytical results are received and validated.

As discussed with EPA and elsewhere in this report, it is the intent of Bridgeton Landfill to work cooperatively with EPA to maximize efficiencies and minimize downtime between investigative steps. To this goal, this work plan will be updated through addenda addressing the next investigational steps and the parties will work cooperatively to streamline comments and revisions to ensure that work can proceed efficiently to completion. The schedule will be optimized with concurrence from the EPA through weekly communication.

The tasks are listed below with the expect field times. Overlapping tasks will occur. The project tasks include:

- Phase 1B Field Investigation - 20 days
- Phase 1B Analytical Testing 30 days
- Phase 1B Data Validation 20 days
- Phase 1C Field Investigation 15 days
- Phase 2 Field Investigation - 40 days
- Phase 2 Analytical Testing 30 days
- Phase 2 Data Validation 20 days
- Final Report Preparation 20 days (after all analytical results are fully validated)

11 REFERENCES

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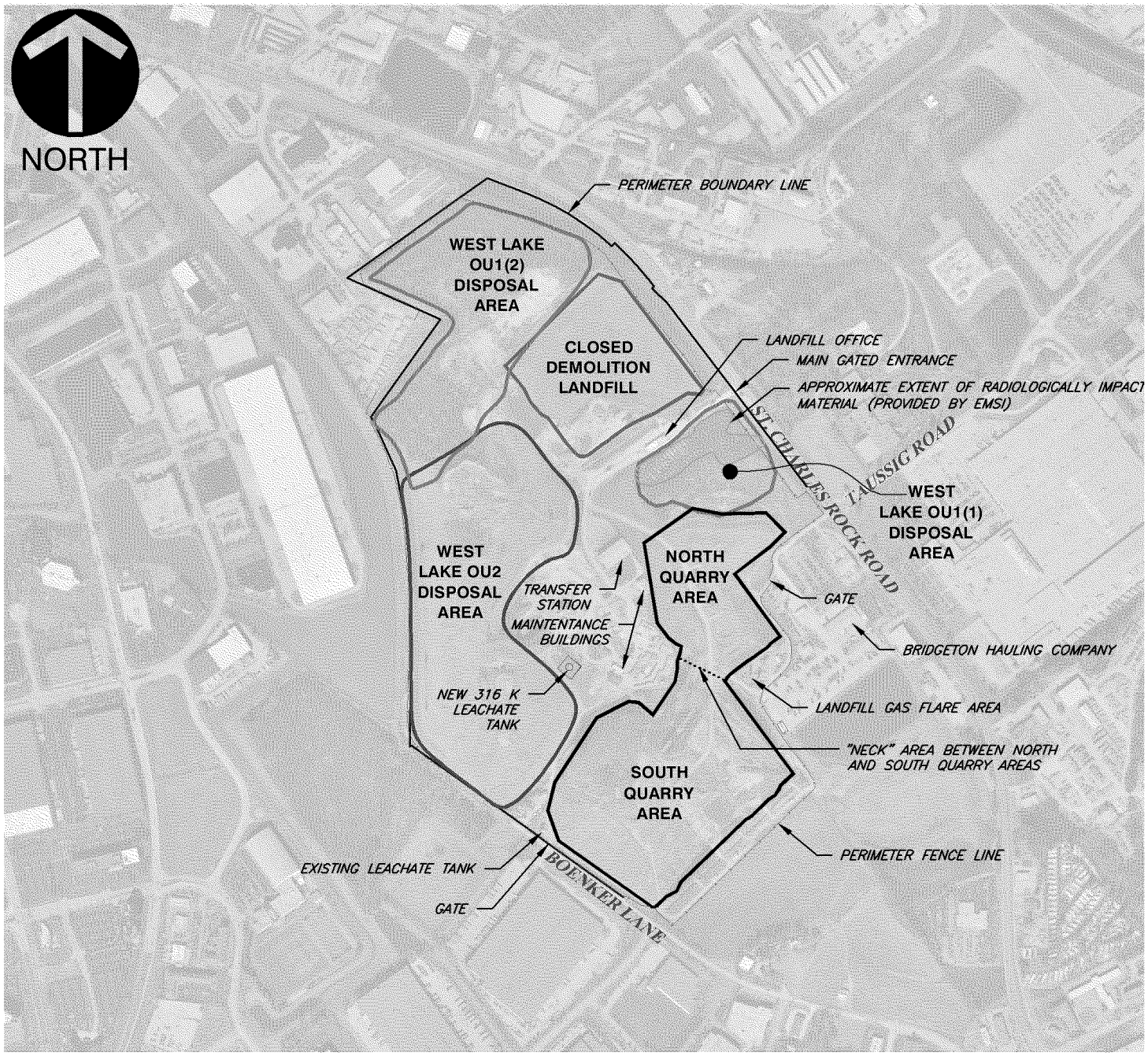
FIGURES



REFERENCE

1. AERIAL IMAGERY PROVIDED BY EAST WEST GATEWAY COORDINATING COUNCIL OF MISSOURI AND ILLINOIS, COLLECTED IN LATE FEBRUARY AND EARLY MARCH OF 2012.
2. BOUNDARY INFORMATION PROVIDED BY SHERBUT–CARSON & ASSOCIATES, P.C. DRAWING NAME–1111 LEASE EXHIBIT.DWG RECEIVED ON 03/04/2013

SCALE IN FEET

0 1000 2000

BRIDGETON LANDFILL, LLC
13570 ST. CHARLES ROCK ROAD
BRIDGETON, MISSOURI

FACILITY MAP

DRAWN BY:	MSP	CHECKED BY:	MRB	APPROVED BY:	DRAFT	FIGURE NO.:	1
DATE:	JUN. 2013	DWG SCALE:	1"=1000'	PROJECT NO:	131-178.0001		

P:\2013\130-484\-CADD\Dwg\SolidWaste\131178-Figure_1.dwg[FACILITY MAP] LS:(6/27/2013 - ccolthorp) - LP: 6/27/2013 11:02 AM

GCPT Boring	Date Completed	Maximum Depth	Maximum Gamma Count	Depth of Maximum Gamma Count
		(feet)	(Counts per Second)	(feet)
GCPT - 1.1	11/25/2013	39.7	124.0	32.5
GCPT - 1.2	11/25/2013	40.2	1,131.3	24.4
GCPT - 2.1	11/24/2013	50.8	93.5	3.3
GCPT - 2.2	11/24/2013	43.1	1,600.0	34.0
GCPT - 2.3	11/24/2013	39.4	578.7	35.6
GCPT - 3.1	11/24/2013	41.2	1,313.5	27.7
GCPT - 3.2	11/24/2013	48.4	103.1	1.0
GCPT - 4.1	11/14/2013	53.1	8,136.6	28.9
GCPT - 4.2	11/14/2013	52.8	677.4	34.0
GCPT - 5.1	11/19/2013	38.0	2,112.3	25.1
GCPT - 5.2	11/18/2013	51.2	1,911.4	26.2
GCPT - 5.3	11/19/2013	44.3	10,527.7	29.4
GCPT - 5.4	11/19/2013	43.6	147.0	11.8
GCPT - 6.2	11/19/2013	48.7	104.3	13.3
GCPT - 6.3	11/19/2013	45.1	1,720.3	27.9
GCPT - 6.4	11/16/2013	25.6	73.9	3.1
GCPT - 6.5	11/16/2013	60.0	101.8	3.3
GCPT - 7.1	11/15/2013	52.0	103.4	7.9
GCPT - 7.2	11/19/2013	50.0	100.2	4.9
GCPT - 7.3	11/16/2013	54.5	209.3	40.0
GCPT - 8.1	11/15/2013	57.1	330.9	29.0
GCPT - 9.1	11/15/2013	47.6	138.0	6.2
GCPT - 9.2	11/19/2013	54.0	97.1	16.9
GCPT - 9.3	11/15/2013	55.9	103.8	15.3
GCPT - 10.1	11/19/2013	47.6	113.8	1.6
GCPT - 10.2	11/20/2013	53.1	108.1	7.7
GCPT - 10.3	11/18/2013	7.2	81.5	3.4
GCPT - 10.4	11/18/2013	54.1	110.7	14.9
GCPT - 11.1	11/21/2013	50.9	153.5	0.2
GCPT - 11.2	11/20/2013	52.2	126.9	15.4
GCPT - 11.3	11/20/2013	53.5	114.3	6.1
GCPT - 11.4	11/18/2013	50.7	163.2	45.9
GCPT - 12.1	11/20/2013	34.1	5,135.0	24.1
GCPT - 12.2	11/20/2013	54.1	109.1	1.3
GCPT - 12.3	11/21/2013	55.4	124.6	4.1
GCPT - 12.4	11/21/2013	57.4	122.9	38.5
GCPT - 12.5	11/21/2013	42.2	107.2	7.5
GCPT - 12.6	11/18/2013	62.7	106.3	23.1
GCPT - 13.1	11/21/2013	22.1	471.7	15.4
GCPT - 13.2	11/21/2013	No boring refusal less than 5 '		
GCPT - 13.3	11/21/2013	No boring refusal less than 5 '		
GCPT - 13.4	11/21/2013	No boring refusal less than 5 '		0.0
GCPT - 13.5	11/22/2013	No boring refusal less than 5 '		0.0
GCPT - 13.6	11/22/2013	8.3	96.7	3.4
GCPT - 13.7	11/22/2013	14.3	98.8	8.9
GCPT - 14.1	11/22/2013	47.5	494.0	18.9
GCPT - 14.2	11/22/2013	No boring refusal less than 5 '		
GCPT - 14.3	11/22/2013	No boring refusal less than 5 '		
GCPT - 14.4	11/22/2013	No boring refusal less than 5 '		
GCPT - 14.5	11/22/2013	11.4	96.2	1.6
GCPT - 14.6	11/22/2013	10.8	110.9	7.4
GCPT - 14.7	11/22/2013	No boring refusal less than 5 '		
GCPT - 15.1	11/23/2013	35.6	199.0	20.3
GCPT - 15.2	11/23/2013	No boring refusal less than 5 '		
GCPT - 15.3	11/23/2013	36.1	163.8	30.5
GCPT - 15.4	11/22/2013	40.2	140.0	29.4
GCPT - 15.5	11/22/2013	60.4	117.4	57.4
GCPT - 15.6	11/22/2013	42.3	118.3	2.6
GCPT - 15.7	11/22/2013	46.8	107.4	2.5
GCPT - 15.8	11/22/2013	29.7	145.4	2.3
GCPT - 16.1	11/23/2013	31.8	153.8	7.2
GCPT - 16.2	11/23/2013	24.9	115.8	1.8
GCPT - 16.3	11/23/2013	30.8	112.4	2.3
GCPT - 16.4	11/23/2013	43.8	124.1	3.0
GCPT - 16.5	11/23/2013	21.9	114.4	4.8
GCPT - 16.6	11/23/2013	25.4	110.0	13.6
GCPT - 16.7	11/23/2013	30.0	106.9	2.6
GCPT - 16.8	11/23/2013	26.9	110.8	20.7
PVC-25	11/14/2013	30.8	1,248.0	8.4
PVC-28	11/14/2013	38.5	1,375.2	24.9
PVC-36 (GCPT - 6.1)	11/14/2013	18.0	324.5	8.5
WL-108	11/15/2013	16.7	106.8	2.0
WL-111	11/13/2013	52.3	159.0	25.9
WL-119	11/15/2013	49.9	243.6	45.6

0 40 80 Feet

LEGEND

- GCPT LOCATION
- ELEVATED DOWNHOLE GAMMA READING
- BOUNDARY OF ELEVATED DOWNHOLE READINGS
- NON-ELEVATED DOWNHOLE GAMMA READING
- BOUNDARY OF NON-ELEVATED DOWNHOLE READINGS
- INTERPOLATED RIM LIMITS
- FENCE
- ROCK

WEST LAKE LANDFILL
13570 ST. CHARLES ROCK ROAD
BRIDGETON, MISSOURI 63044

WEST LAKE LANDFILL OU-1
AREA 1 RIM INVESTIGATION

FEEZOR ENGINEERING, INC.
Engineering for a Better World

GCPT STATUS through 11-29-13

DECEMBER 2013
DESIGNED BY: PML
APPROVED BY: DRF

DRAWING NO.: 2

PROJECT NUMBER: BT-012 | FILE PATH:

REVISION | DATE

WLLFOIA4312 - 001 - 0049123

LEGEND

- GCPT LOCATION
- ELEVATED DOWNHOLE GAMMA READING
- BOUNDARY OF ELEVATED DOWNHOLE READINGS
- NON-ELEVATED DOWNHOLE GAMMA READING
- BOUNDARY OF NON-ELEVATED DOWNHOLE READINGS
- INTERPOLATED RIM LIMITS
- FENCE
- ROCK
- PROPOSED PHASE 1B SONIC BORING LOCATION
- PROPOSED PHASE 1C BORING LOCATION (EITHER SONIC DRILLED OR GCPT)

WEST LAKE LANDFILL
13570 ST. CHARLES ROCK ROAD
BRIDGETON, MISSOURI 63044

WEST LAKE LANDFILL OU-1
AREA 1 RIM INVESTIGATION

Engineering for a Better World
FEEZOR ENGINEERING, INC.

PROPOSED PHASE 1B AND 1C BORING LOCATIONS

DECEMBER 2013
DESIGNED BY: PML
APPROVED BY: DRF

DRAWING NO.: **3**

PROJECT NUMBER: BT-012 | FILE PATH:

REVISION | DATE

WLLFO\A4312 - 001 - 0049124

Appendix A

Auxier & Associates Radiological Surveying and Sampling Procedures

PROCEDURE 2.1
INSTRUMENTATION: CALIBRATION & QUALITY CONTROL

1.0 PURPOSE

1.1 To describe the general approach to calibration and quality control checks of survey instruments.

2.0 RESPONSIBILITIES

2.1 The Site Survey Manager is responsible for assuring that this procedure is implemented.

2.2 Survey team members are responsible for following this procedure.

3.0 PROCEDURE

3.1 Calibration

3.1.1 Instruments to be used for quantitative measurements are source calibrated a minimum of every twelve months; more frequent calibration may be necessary for some projects or applications to satisfy requirements of the responsible regulatory agency or following repair of the instrument. Exception: A properly calibrated Pressurized Ionization Chamber may be used as a secondary standard to calibrate response of a gamma detector, relative to true exposure rate (refer to Procedure 2.5).

3.1.2 Calibration is to be performed with standards traceable to the National Institute of Standards and Technology (NIST) or other industry recognized standards organizations.

3.1.3 Records will be maintained for each detector and readout instrument, detailing the calibration and maintenance history. Originals of calibration records are to be maintained at the Knoxville, Tennessee facility; however, copies should accompany instruments to the field measurement location.

3.1.4 Calibration will be performed by the instrume nt manufacturer or other outside organization. A&A will provide directions/specifications for calibration by outside agencies. An exception to manufacturer calibration is calibration of gamma detectors, using a pressurized ionization chamber (see Procedure 2.5). Calibration for response of surface contamination

monitors to radionuclides or radionuclide mixtures for which commercial calibration services are not available or practical may necessitate in-house determination of source response or theoretical calculation of response, based on estimated parameters, e.g., from draft NUREG-1507. If in-house calibration is performed, detailed procedures will be developed, approved by the Field Survey Resources Committee, and placed in the appropriate project file.

3.1.5 Instruments, such as a pressurized ionization chamber, may be calibrated as a detector/readout combination; if calibrated in this manner, quantitative measurements are made only with the components and parameters for which the combination was calibrated.

3.1.6 Detectors and readouts, which are individual pieces of equipment, are usually calibrated separately; however, a calibrated detector may be used with various calibrated readout instruments, even if a specific source calibration of the combination has not been performed. To enable such use, the baseline response of the calibrated detector to a designated check source is determined immediately after return of the detector from calibration, using a readout instrument (for which the calibration is also current) with the operating parameters, e.g., high voltage and threshold (input discriminator), set according to those parameters at which the detector was calibrated.

Where possible, for an analog readout instrument, select a scale on which the source will provide a reading of between half- and full-scale; for an integrating digital readout instrument select a count time which will result in accumulation of at least 10,000 counts. Determine and record on the appropriate form, the gross and net instrument response on the Baseline Response record form. For instruments that will be operated in the scaler mode, repeat the determination ten times and calculate the average; one reading is recorded for instruments to be operated in the ratemeter mode. A range of ± 20 % of that response to the designated source is established as the criterion for evaluating acceptance of other readouts (with properly set operating parameters) with that detector. Each detector/readout combination, which satisfies the acceptance criterion for the designated baseline check source may be assumed to be responding with the efficiency established for the detector. This record is filed with other detector response, calibration, and maintenance information.

3.2 Quality Control Check

3.2.1 Equipment

3.2.1.1 Instrument (detector and/or readout)

3.2.1.2 Cables

3.2.1.3 Check source

3.2.1.4 Pulse generator (Ludlum Measurements, Inc. Model 500)

3.2.1.5 Calibration documents

3.2.1.6 Forms for Baseline Detector Response and Instrument QC Check

3.2.2 Procedure

3.2.2.1 This procedure is applicable to all field survey instruments.

3.2.2.2 Quality control checks are performed prior to sending instruments to the field, at the beginning and end of each day of data acquisition, upon return of the instrument from a field assignment, at any time instrument factors (batteries, cables, operating parameters, etc.) which could effect the instrument response are altered, and whenever the performance of an instrument is in question.

3.2.2.3 Assure that the baseline response has been established, that the response to the check source has been determined, and that the response was satisfactory (refer to Step 3.1.6).

3.2.2.4 All equipment associated with instrument operation (e.g., tubing, flow meters, collimators, headphones, etc.) should be in place when testing response to assure proper operation of the complete system.

3.2.2.5 Turn the instrument on and check batteries. Record result on Instrument QC check form; replace batteries and repeat test, if necessary.

3.2.2.6 Check high voltage, threshold, and other operating parameters; record values and, if necessary, adjust parameters to predetermined values and repeat checks. For some instruments it will be necessary to use the Ludlum Pulse Generator to determine and adjust the operating parameters.

3.2.2.7 Determine and record the instruments' baseline responses. The site-specific baselines will be determined at each site at a location selected by the Site Survey. Typical baseline instrument responses are as follows:

Table 2.1-1 Expected Baseline Instrument Responses

Instrument /Detector	Typical Baseline Response	Baseline Responses in Bridgeton Trailer
Ludlum Model 19	5 to 15 µR/h	5 to 7 µR/h
Bicron Microrem meter	3 to 10 µrem/h	-
Ludlum Mo 12 w/ Mo 44-2	700 to 2,400 counts/min	1,000 to 1,300 counts/min
Ludlum Mo 2221 w/ Mo 44-10	4,000 to 14,000 counts/min	4,000 to 5,100 counts/min
Ludlum Mo 2221 w/ Mo 44-20	7,000 to 23,000 counts/min	10,000 to 14,000 counts/min
Ludlum Mo12 w/ Mo 43-5	0 to 8 counts/min	0 to 5 counts/min
Ludlum Mo12 w/ Mo 44-9	20 to 60 counts/min	25 to 50 counts/min

3.2.2.8 Place the baseline check source in contact with the detector and determine and record the analog or integrated digital response, as appropriate. Calculate the net response and compare with the previously established acceptable baseline response range. If the source falls within that range, the instrument may be considered to be operating properly. If the response does not fall within the acceptable range, the instrument should not be used for quantitative measurements unless a thorough evaluation justifies otherwise.

3.2.2.9 If the instrument response to the baseline source is acceptable, select a QC check source and place the appropriate surface in contact with the designated location on the detector or instrument. Turn on the audible output to confirm its operation.

3.2.2.10 Where possible, for an analog readout instrument, select a scale on which the QC check source will provide a reading of between half- and full-scale; for an integrating digital readout instrument select a count time which will result in accumulation of at least 10,000 counts. Determine and record the gross and net instrument response on the appropriate form. For instruments that will be operated in the scaler mode, repeat the determination ten times and calculate the average; one reading is recorded for instrument to be operated in the ratemeter mode. Calculate and

enter the range of acceptable instrument response as the average ± 20%.

3.2.2.11 To check response of the instrument, relative to the predetermined acceptable QC response range, place the source at the designated source test position and determine and record the analog or integrated digital response, as appropriate. Calculate the net response and compare with the previously established acceptable response range. If the source falls with that range, the instrument may be considered to be operating properly. If the response does not fall within the acceptable range, data recorded since the previous acceptable test should be considered questionable, and not used for quantitative purposes, unless a thorough evaluation justifies otherwise.

PROCEDURE 2.3
DIRECT RADIATION MEASUREMENT

1.0 PURPOSE

1.1 To describe the method for measuring total alpha and beta radiation levels on equipment and building surfaces.

2.0 RESPONSIBILITIES

2.1 The Site Survey Manager is responsible for assuring that this procedure is implemented.

2.2 Survey team members are responsible for following this procedure.

3.0 PROCEDURE

3.1 Equipment

3.1.1 Ratemeter-scaler: Model 3, Model 2220 or 2221, Ludlum Instrument Corporation; or equivalent

3.1.2 Detector: Selected detectors are listed below: Equivalent detectors are also acceptable

Activity	Detector Type	Model
alpha	ZnS scintillator	Ludlum 43-1 or 43-5, Eberline AC3-7 or AC3-8
	gas proportional	Ludlum 43-68
beta	Geiger-Mueller	Ludlum 44-9, Eberline HP-260
	gas proportional	Ludlum 43-68

3.1.3 Cables

3.1.4 Check source

3.1.5 Record forms

3.2 Quality Control Check

3.2.1 Assemble instrument, turn on, check battery, and adjust high voltage and threshold, if necessary. Check background and check source responses. Follow the procedures described in Procedure 2.1.

3.3 Direct Measurement

3.3.1 When applicable, team members performing instrument checks will calculate the average and maximum "field action levels" for instrument combination based on the specific site criteria and background.

Action level (cpm) = [site criteria (dpm/100 cm^2) x E x G x T] + B

T = count time (minutes)
E = operating efficiency (counts/disintegration)
G = geometry (total detector area (cm^2)/100)

	Total Area	Active Area
43-5 detector area =	80 cm^2	60 cm^2
43-1 detector area =	80 cm^2	50 cm^2
43-68 detector area =	126 cm^2	100 cm^2
44-9 detector area =	20 cm^2	15.5 cm^2
HP-260 detector area =	20 cm^2	15.5 cm^2

B = background (cpm)

A field count at or above this value indicates that further investigation in this location is necessary.

NOTE: For a particular site, the action level may be established as any activity exceeding background.

3.3.2 Select an appropriate counting time. A counting time is desired which will achieve a minimum detectable activity (see Procedure 4.2) value less than 50% of the applicable criteria. For most radionuclides a 1-minute count, using the instruments listed above, is adequate to achieve this sensitivity. For radionuclides having guidelines of 5000 dpm/100 cm^2, average and 15,000 dpm/100 cm^2, maximum, 0.5 minute counting times may be acceptable.

3.3.3 Place the detector face in contact with the surface to be surveyed. The detector face is typically constructed of a very thin and fragile material, so care must be exercised to avoid damage by rough surfaces or sharp objects. (Scans should have been performed, prior to this point, to identify representative locations and locations of elevated direct surface radiation for measurement.)

3.3.4 Set the meter timer switch, press the count-reset button, and accumulate the count events until the meter display indicates that the count cycle is complete.

3.3.5 Record the count and time on the appropriate record form.

3.3.6 If the location has a surface activity level above background, the area around the measurement locations should be scanned to determine the homogeneity of the measured activity level in the area. Dimensions and activity levels of inhomogeneities should be documented on the appropriate record form.

3.3.7 The surface activity may be calculated according to Procedure 4.3.

PROCEDURE 2.6
SUBSURFACE SCANNING (BOREHOLE LOGGING) AND SAMPLING

1.0 PURPOSE

1.0 To describe the method for performing subsurface sampling and vertical scanning.

1.1 Subsurface scanning indicates locations and relative levels of radioactivity.

2.0 RESPONSIBILITIES

2.0 The Site Survey Manager is responsible for assuring that this procedure is implemented.

2.1 Survey team members are responsible for following this procedure.

3.0 MATERIALS

3.1 Instrumentation

3.1.1 Bicron microrem meter or comparable tissue equivalent dose meter.

3.1.2 Portable ratemeter-scaler: Model 3, Model 12, Model 2241 or Model 2221 Ludlum Measurements, Inc.; or equivalent.

3.1.3 Sodium iodide detector: Model 44-2, Ludlum Measurements, Inc.; Model SPA-3 or PG-2, Eberline Instrument Corporation; or equivalent.

3.1.4 Cables of sufficient length to reach the bottom of the deepest borehole.

3.2 Supplemental Equipment

3.2.1 Light rope or cable of sufficient strength and length to lower detector to the bottom of the deepest borehole and retrieve it. Rope should be clearly marked in 6-inch (15-cm) increments.

3.2.2 Clamp or tape to secure rope to detector.

3.2.3 Optional lead collimator for scintillation probe. Collimator design based on specific project needs.[1]

3.2.4 Optional winch assembly for lowering and raising detector in deep boreholes.

3.2.5 Plastic (PVC) pipe, as required, of sufficient length and diameter to encase borehole to the desired logging depth. The pipe diameter will be determined by the dimensions of the drillbit or soil probe.

For example, a 2-inch I.D. (internal diameter) Schedule 40 PVC pipe is recommended for most applications involving a Model 44-2 (1-inch

[1] NOTE: Borehole logging can be done using a bare or collimated NaI detector. Uncollimated detectors are used for shallow or small diameter boreholes or for collecting general information concerning the vertical distribution of radioactive material in the borehole. Therefore, depending on the specific needs of the survey, items 3.2.3 and 3.2.4 are optional and are typically used for boreholes measuring 3 meters or greater in depth.

sodium iodine) detector. This size pipe requires installation of a 2.5 inch diameter or larger borehole.

3.2.6 One PVC pipe end cap for each planned borehole, plus at least two extra end caps for contingencies.

3.2.7 PVC Pipe cement.

3.2.8 A saw or PVC pipe cutter to size PVC pipe lengths.

3.2.9 Plastic bags large enough to cover detector assembly when down hole.

3.2.10 Record forms and pens.

3.2 Boring Equipment

3.2.1 Geoprobe with 3.25 inch sampling barrel and tool string.

3.2.2 Enough tube inserts for the 3.25 inch barrel to accommodate planned sampling at all locations and depths with extra for wastage.

3.2.3 Two tube caps for each insert.

3.0 INSTRUMENT ASSEMBLY

3.1 Assemble instrument/detector combination with long cable.

3.2 Securely attach support rope to detector. Use tape or wire ties to secure cable to support rope at approximately 1-meter intervals. Leave about 1-2 inches of slack in cable between the top of the detector and the first piece of tape or wire tie binding the rope to the cable.

NOTE: The weight of the detector should always be supported by a rope or equivalent. The detector should NEVER be lifted or supported by the long instrument cable.

3.3 Perform daily instrument check on assembled unit as described in Procedure 2.1.

4.0 SITE PREPARATION PRIOR TO INSTALLATION OF A BOREHOLE

4.1 Refer to the Project Sampling Plan for the location of selected borehole.

4.2 (Optional) Have a licensed surveyor locate and clearly mark all sampling locations

4.2 Proceed to selected borehole location and record its coordinates using GPS coordinates and a unique borehole description or identification number.

4.3 Using a microrem meter, collect and record the dose rate, in mrem/h, at 1-meter above the ground.

4.4 Using the selected meter and detector combination (see 3.0, above), collect and record a 30 second measurement, in cpm, at 1 centimeter (~0.5 inch) above the ground.

5.0 SUBSURFACE SAMPLING PROCEDURE

5.1 USING A GEOPROBE

5.1.1 Position GeoProbe with a 3.25 inch soil probe (e.g. barrel) over the desired location of the borehole.

5.1.2 Collect the first soil core from hole.

5.1.3 Extract the tube liner containing soil core from the coring tool and cap the

liner's ends. Seal the ends with electrical tape.

5.1.4 Use indelible ink to mark each liner with a) an arrow pointing to the top of the soil sample, b) the unique location identifier, and c) an estimate of the sample depth interval recovered (For example: ←Top, NSU#1, 0-22 inches).

5.1.5 Use the Geoprobe to collect the next soil core from the hole.

5.1.6 Extract the tube liner containing soil core from the coring tool and cap the liner's ends. Seal the ends with electrical tape.

5.1.7 All tubes containing soil must be handled and stored in the vertical position with the top up.

5.1.8 Use indelible ink to mark each liner with a) an arrow pointing to the top of the soil sample , b) the unique location identifier, and c) an estimate of the sample depth interval recovered (For example:←Top, NSU#1, 23-41 inches).

5.1.9 If required, soil tubes can be scanned by a variety of instruments after they are sealed and properly labeled. If this is required, the instruments and scanning method will be specified in project specific documentation.

5.1.10 Labeled sample tubes containing soil can be stored in an upright 85 gallon drum until soil sample depths are identified from logging data.

5.11 Continue repeating steps 5.5 and 5.9 until the desired depth is reached or until refusal.

5.12 Once borehole sampling is complete, cut PVP pipe to a length that is equal to the depth of the borehole plus about 4 inches and glue one end-cap on PVP pipe. Place PVP pipe into hole (end cap on bottom and open end up). Push PVP pipe into hole until pipe is firmly seated in hole.

5.13 Move the Geoprobe to next hole.

5.2 USING A HAND AUGER

5.2.1 Position auger (using a 3 inch diameter soil bucket) over the desired location of the borehole.

5.2.2 Collect the first 6" of soil from hole.

5.2.3 Empty auger bucket into a bag lined 5 gallon bucket (or equivalent) marked with 0-1'.

5.2.4 Retrieve next 6" soil increment from hole and place in the 0-1' bucket.

5.2.5 Decon auger bucket between each 1' increment.

5.2.6 Using the same method for each 6" increment, empty each 1 foot increment into a uniquely identified bag lined 5 gallon bucket corresponding to that particular depth.

5.2.7 If required, 5 gallon buckets can be scanned by a variety of instruments after all properly labeled buckets are transported to the sample preparation area. If this is required, the instruments and scanning method will be specified in project specific documentation.

5.2.8 Continue repeating steps 5.2.5 through 5.2.7 until the desired depth is reached or until refusal.

5.2.9 Once borehole sampling is complete, cut a PVP pipe (or equivalent) to a length that is equal to the depth of the borehole plus about 4 inches and glue one end-cap on PVP pipe. Push PVP pipe into hole until pipe is firmly seated in the hole (end cap on bottom and open end up).

5.2.10 Survey the sampling equipment and decon with water as needed. Move the auger equipment to next hole.

5.2.11 Perform a gamma log of the borehole (see Section 7).

5.2.11 Remove PVC pipe from hole and backfill hole if required.

6.0 DOWNHOLE LOGGING PROCEDURE

6.1 Prior to inserting the detector down-hole, enclose the detector assembly, including the collimator if in use, in double plastic bags or tubular sheeting to protect detector against direct contact with water or soil from the borehole.

6.2 Set the scaler timer to accumulate counts over a period of 0.5 or 1 minute, depending upon contaminant and ambient detection level.

6.3 (Optional) If using the winch assembly, place it over the borehole.

6.4 Position the detector over the hole with bottom of the detector level with the ground surface. If using the collimator assembly, position the slots level with the ground surface.

6.5 Record this initial position as the 0 centimeter or surface measurement. If using the collimator assembly, reset the depth recorder to 0. Collect the first timed measurement and record the results, in cpm, at this position.

6.6 Lower the detector slowly into the borehole, stopping at 6 inch intervals to collect and record timed measurements in cpm. Record the depths of these locations.

6.7 When the detector reaches the bottom of the borehole or borehole liner pipe record the last measurement and depth of the hole.

6.8 Raise the detector to the surface and inspect the detector for signs of water infiltration into the plastic cover. Clean the cover or replace it, as needed.

7.0 COLLECTION OF SOIL SAMPLES

7.1 FROM GEOPROBE SOIL TUBES

7.1.1 Once downhole logging is complete, the series of downhole radiation measurements from that borehole will be analyzed and a number of samples may be extracted from the soil tubes. The number and depths of these samples will be determined by the sampling plan or the supervisor of the sampling task.

7.1.2 The sample depth will generally be determined as the sum of the recovered soil in the sampling tubes, not the length of the plastic tube containing the soil.

7.1.3 Soil samples will be processed as described in Procedures 2.8 (preparation of Transportation, 3.3 (Soil Sampling), and 3.7 (Sample Identification).

7.2 FROM AUGERED SOIL IN BUCKETS

7.2.1 Once downhole logging is complete, the series of downhole radiation measurements from that borehole will be analyzed and a number of

samples may be extracted from the plastic-lined buckets holding the soil samples collected at specific depth. The number and depths of these samples will be determined by the sampling plan or the supervisor of the sampling task.

7.2.2 Soil samples will be processed as described in Procedures 2.8 (preparation of Transportation, 3.3 (Soil Sampling), and 3.7 (Sample Identification).

PROCEDURE 2.7
MONITORING PERSONNEL AND EQUIPMENT FOR RADIOACTIVE CONTAMINATION

1.0 PURPOSE

1.1 To describe the general approach for monitoring personnel and equipment for radioactive contamination.

2.0 RESPONSIBILITIES

2.1 The Site Survey Manager is responsible for assuring that this procedure is implemented.

2.2 Survey team members are responsible for following this procedure.

3.0 PROCEDURE

3.1 Upon exiting potentially contaminated areas, monitoring of clothing and exposed skin surfaces will be performed. Equipment and materials will also be monitored and shown to be free of contamination before release for use without radiological restrictions or controls.

3.2 Equipment

3.2.1 Ratemeter-scaler: Model 3 or Model 2221, Ludlum Measurements, Inc.; or equivalent, equipped with audible speaker or headphones.

3.2.2 Detector: Selected detectors are indicated below. Equivalent detectors are also acceptable.

Activity	Detector Type	Model
Alpha	ZnS scintillator	Ludlum 43-1 or 43-5, Eberline AC3-7 or AC3-8
	Gas proportional	Ludlum 43-68, Ludlum 239-1
Beta	Gas proportional	Ludlum 43-68, Ludlum 239-1
	Geiger-Mueller	Ludlum 44-9, Eberline HP-260

3.2.3 Instrument cables

3.2.4 Check sources

3.2.5 Record Forms and/or field logbook

3.3 Quality Control Check

Assemble instrument, turn on, check battery, and adjust high voltage and threshold, if necessary. Check background and source responses following Procedure 2.1.

3.4 Surface Scanning

3.4.1 Headphones or other audible signal operating modes are used for scanning.

3.4.2 Set the instrument response for "FAST", response where possible.

3.4.3 Pass the detector slowly over the surface. The detector should be kept as close to the surface as conditions allow. The speed of detector movement will vary depending upon the radionuclide of concern and the experience of the surveyor. While scanning for alpha or beta activity, the detector is typically moved about one detector width per second.

3.4.5 Note increases in count rate as indicated by the audible meter output. Identifiable increases in the audible response suggest possible contamination and should be resurveyed at a slower rate to confirm findings.

3.5 Personnel Monitoring

3.5.1 When monitoring for skin or clothing contamination, give particular attention to the hands, shoes, pant and shirt cuffs, knees, and other surfaces which have a high likelih ood of contamination.

3.5.2 If there is detectable contamination, it should be removed as directed by the Health and Safety Committee (HSC) Chairperson. Decontamination guidance will be provided in the Survey Work Plan. The Site Safety Officer will implement decontamination or other contamination control actions at the project site.

3.6 Equipment Monitoring

3.6.1 For equipment surveys, attention should be given to monitoring cracks, openings, joints, and other areas where contamination might accumulate.

3.6.2 Measure levels of total and removable surface contamination (see Procedures 2.3 and 3.6) at locations of elevated direct radiation identified by the scan and at additional representative surface locations.

3.6.3 Acceptable surface contamination levels will be established on a project-specific basis, with details, including decontamination instructions, provided in the Survey Work Plan.

3.7 Document results of contamination surveys in field records.

PROCEDURE 2.8
PREPARING SAMPLES FOR TRANSPORTATION

1.0 PURPOSE

1.1 To provide guidance for preparing samples for transportation to assure regulatory compliance.

2.0 RESPONSIBILITIES

2.1 The Site Survey Manager is responsible for assuring this procedure is implemented.

2.2 Survey team members are responsible for following this procedure.

2.3 The Health and Safety Committee will assist in preparing appropriate criteria for potential shipments, including specific radiation action levels at appropriate distances from the container's surface.

3.0 PROCEDURE

3.1 Overview of regulations: Regulations for transportation of samples containing small quantities of radioactivity are set forth in 49 CFR 173, Subpart I. The regulations take a graded approach, and shipments containing greater radioactivity will generally be required to follow more stringent shipping requirements

For transportation purposes, radioactive material is defined in 49 CFR 173.403 as "... any material containing radionuclides where both the activity concentration and the total activity in the consignment exceed the values specified in the table in §173.436 or values derived according to the instructions in §173.433." These activities are reproduced in Table 2.8-1 for a subset of radionuclides.

It is important to note that 49 CFR 173.401(b)(4) states that Subpart I does not apply to "...(n)atural material and ores containing naturally occurring radionuclides which are not intended to be processed for use of these radionuclides, provided the activity concentration of the material does not exceed 10 times the values specified in §173.436."

3.2 Applicability and Additional Considerations: For the purpose of shipping most samples collected from environmental media, are expected to be either excepted, or classified as non-radioactive for shipping purposes. If the sample shipment

exceeds the limits specified in Table 2.8-1, this procedure does not apply, and special handling will be required.

In addition to requirements imposed by transportation regulations, the analytical laboratory or other receiver of the shipped samples may have further restrictions or requirements which must be considered in preparation of the shipment.

The Health and Safety Committee will assist in preparing appropriate criteria for potential shipments, including specific radiation action levels at the container surface, at 30 cm from the surface, and at 1 m from the surface. Special packaging and labeling instructions will also be developed. This information will be incorporated into the Survey Work Plan.

3.3 The following is the process for preparing samples for transportation:

3.3.1 Select an appropriate outer container for the samples. The container must be strong and capable of retaining contents during conditions normally incident to transportation. A typical container used by A&A is a 48 quart plastic cooler.

3.3.2 Place a plastic liner inside the container. A plastic garbage bag works well.

3.3.3 Place the samples into the lined container. Do not exceed a net sample weight (including the individual sample containers) of 29 kg.

3.3.4 Scan the outside of the loaded container with a gamma detector (Procedure 2.2) to determine the location of the maximum radiation level.

3.3.5 Measure the radiation level (see Procedure 2.4) at a distance of 30 cm from the location on the container identified in Step 3.3. Record the results on the sample chain of custody form.

3.3.6 Compare the measurement obtained with the exposure rate action levels provided in the Survey Work Plan. If the radiation levels satisfy the criteria , the shipment is excepted from all manifesting and labeling requirements. [2] Contact the HSC Chairperson or the project manager if the package still does not meet the specified action levels.

3.3.7 Mark the outside of the inner lining with the UN identification number UN2910. This can be hand written using a black marker.

3.3.8 Fill spaces in the container liner with packing material to restrict sample movement during transport. If the container includes any freestanding

[2] For certain radionuclides, this concentration limit can be demonstrated by measurement of the direct radiation level associated with the package. For example, if the contaminant is oil-field NORM, calculations and experience have shown that the activity concentration limit will be satisfied if the direct radiation level at 30 cm from the package exterior (assuming a typical 48 quart cooler, used by A&A for sample shipping) is less than 20 µR/h (or 20 µrem/h), above background. For other radionuclides, the relationship between concentration and direct radiation level may differ from that of Ra-226, and appropriate decision levels must therefore be established for each project.

liquids, include twice the sufficient absorbent material to absorb the liquid contents, in case of leakage.

3.3.9 Seal the inner plastic liner in a manner that leaves the UN number clearly visible.

3.3.10 Place the Chain-of-Custody form and other paperwork on top of the inner liner.

3.3.11 Close and seal the outer container.

3.3.12 Complete shipping papers. If the package is "Exempt", shipping papers are the same as if the shipment did not contain radioactive material.

3.3.13 Attach the shipping papers and initiate the shipment.

Table 2.8-1 Table of Exempt Material Activity Concentrations and Exempt Consignment Activity Limits Found in 49 CFR 173

Symbol of radionuclide [2]	Activity concentration for exempt material (pCi/g)	Parent radionuclide's average activity concentration in exempt package (pCi/g) [3,4]	Activity limit for exempt consignment (pCi)	Activity limit of parent radionuclide for exempt consignment (pCi) [3,4]
Am-241	27	27	2.7E+5	2.7E+5
C-14	2.7E+5	270000	2.7E+8	2.7E+8
Co-60	270	270	2.7E+6	2.7E+6
Cs-137 (b)	270	135	2.7E+5	1.4E+5
K-40	2700	2700 (27000)	2.7E+7	3E+7 (3E+8)
Pb-210 (b)	270	90 (900)	2.7E+5	9E+4 (9E+5)
NORM scale	270	30 (300)	2.7E+5	2E+4 (2E+5)
Ra-224 (b)	270	45 (450)	2.7E+6	5E+5 (5E+6)
Ra-226 (b)	270	30 (300)	2.7E+5	3E+4 (3E+5)
Ra-228 (b)	270	135 (1350)	2.7E+6	1E+6 (1E+7)
Rb(nat)	2.7E+5	3E+5 (3E+6)	2.7E+8	3E+8 (3E+9)
Sr-90 (b)	2700	1350	2.7E+5	1.4E+5
Th-228 (b)	27	4 (39)	2.7E+5	4E+4 (4E+5)
Th-230	27	27 (270)	2.7E+5	3E+5 (3E+6)
Th-232	270	135 (1350)	2.7E+5	1E+5 (1E+6)
Th (nat) (b)	27	3 (27)	2.7E+4	3E+3 (3E+4)
U (nat) (b)	27	2 (19)	2.7E+4	2E+3 (2E+4)
U (enriched to 20% or less)(g)	27	27	2.7E+4	2.7E+4
U (dep)	27	27	2.7E+4	2.7E+4

1 69 FR 3685, Jan 26, 2004

2 +D indicates the sum of the activities of the parent and specified daughters should be compared to exempt values

3 Derived values account for presence of daughters and incorporate 10x modifier for natural origin, if applicable.

PROCEDURE 3.3
SOIL SAMPLING

1.0 PURPOSE

To describe the procedures for collecting soil samples.

2.0 RESPONSIBILITIES

2.1 The Site Survey Manager is responsible for assuring that this procedure is implemented.

2.2 Survey team members are responsible for following this procedure.

3.0 EQUIPMENT

3.1 Digging implement: garden trowel, shovel, spoons, post-hole digger, etc

3.2 Special sampling apparatus (cup cutter, shelby tube, metal or plastic tube, etc.) as required

3.3 Drilling equipment: drilling rig, portable motorized auger, manual auger

3.4 Subsurface sampling apparatus: split-spoon sampler, shelby tube sampler

3.5 Sample containers

3.6 Tape

3.7 Indelible pen

3.8 Labels and security seals

3.9 Equipment cleaning supplies, as appropriate

3.10 Record forms and/or logbook

4.0 PROCEDURE

4.1 NOTE: Typically, soil contamination criteria for radionuclides are applicable to the average concentration in 15 cm layers of soil, therefore, the sampling protocols described here are based on sampling 15 cm increments. The method used to sample soil will depend on the specific application and objective. Therefore, several techniques are described in this procedure and selection will be on a site-specific basis. Special situations (e.g., evaluating trends or airborne deposition, determining near-surface contamination profiles, and measuring non-radiological contaminants, necessitate special sampling procedures. These special situations are evaluated and incorporated into site specific survey plans as the need arises.

4.1.1 Direct surface and 1 meter gamma radiation measurements may be performed at each location before initiating sampling. This will identify the presence of gross radionuclide contamination that will require special handling and equipment cleanup procedures. If contamination is suspected, a beta-gamma "open" and "closed" measurement may also be desired before sampling begins.

4.2 Surface Soil

4.2.1 Loosen the soil at the selected sampling location to a depth of 15 cm, using a trowel or other digging implement.

4.2.2 Remove large rocks, vegetation, and foreign objects (these items may also be collected as separate samples, if appropriate).

4.2.3 Place approximately 1 kg of this soil into the sample container. If it is not possible to reach a depth of 15 cm using a hand tool (i.e. trowel or shovel) 1 kilogram of soil should be collected from the accessible depth. The actual depth should be recorded on the sample container and the appropriate record form.

4.2.4 Seal the bag using a twist-tie, cap, and tape the cap in place (or tie the sample bag strings).

4.2.5 Label and secure the sample container in accordance with Procedures 3.7 and 3.8. Record pertinent information on the Chain-of-Custody Form.

4.2.6 Record sample identification, location, and other pertinent data on appropriate record forms, maps, drawings, and/or site logbook.

4.2.7 If the location has been identified as having elevated activity, a measurement should be obtained after the sample is collected to determine the possibility of contaminati on at a depth greater than 15 centimeters. If a subsurface sample is deemed necessary, refer to the appropriate section below.

4.2.8 Clean sampling tools, as necessary, according to the procedure in the Quality Assurance Plan, before proceeding with further sampling.

4.3 Subsurface Soil (Option 1)

4.3.1 Procedure applicable to depths of approximately 3 m when boreholes or trenches have been dug and remain uncollapsed or do not contain water.

4.3.2 When direct radiation measurements are required (surface and borehole logging) they are to be performed prior to sample collection in order to identify the presence of gross radionuclide contamination requiring special handling or cleanup (see the Quality Assurance Plan and/or Health and Safety Plan). If borehole logging is to be done it should be completed before sampling begins (see Procedure 2.6).

4.3.3 Place a plastic bag liner into the downhole sampler and secure with a large rubber band.

4.3.4 Lower the sampling tool to the desired depth in the borehole or trench.

4.3.5 Scrape the inside bor ehole or trench wall with the toothed edge of the tool until approximately 1 kg of sample is collected.

4.3.6 Transfer the plastic bag and sample into the container.

4.3.7 Seal the bag using a twist-tie, cap, and tape the cap in place (or tie sample bag ties).

4.3.8 Labe l and secure the sample container in accordance with Procedures 3.7 and 3.8. Record pertinent information on the Chain-of-Custody Form.

4.3.9 Record sample identification, location, depth, and other pertinent data on the appropriate record forms, map, drawing, and/or site logbook.

4.3.10 Clean sampling tools, as necessary, in accordance with instructions in the Quality Assurance Plan, before proceeding with further sample collection.

4.4 Fixed Geometry and Subsurface Soil (Option 2)

4.4.1 This procedure is appropriate for sampling at depths exceeding 3 m, in boreholes where walls do not remain intact or that fill with water and in situations where it is necessary to retain the orientation of the sample. An example where the latter may be the case, would be when it was necessary to analyze segmented aliquots to determine radionuclide concentrations as a function of depth. This approach could incorporate surface sampling as well as subsurface sampling.

4.4.2 If necessary, drill the borehole to the desired sampling depth using an auger.

4.4.3 Drive a split-spoon, shelby tube, or similar design sample collector through the specified sampling depth.

4.4.4 Withdraw the collecting device; the collected core may be removed at this time.

4.4.5 If the collected core is removed, place the entire core, or a portion of the core, into a sample container. The core may be split into multiple segments, representing different sampling depths. If the core is to remain in the sampling device, the ends are sealed and the orientation noted.

4.4.6 Label and secure the sample container in accordance with Procedures 3.7 and 3.8. Record pertinent information on the Chain-of-Custody Form.

4.4.7 Record sample identification, location, depth, and other pertinent data on the appropriate record forms, map, drawing, and/or site logbook.

4.4.8 Monitor the sample hole to determine activity level. If the activity level is elevated, it may be desirable to repeat items 4.4.1 - 4.4.6. If the activity level has dropped to background, record the measurement and monitor the area, including personnel and equipment, to determine the extent of decontamination that may be necessary.

4.4.9 Clean sampling tools, as necessary, in accordance with instructions in the Quality Assurance Plan, before proceeding with further sample collection.

PROCEDURE 3.6
REMOVABLE ACTIVITY SAMPLING

1.0 PURPOSE

1.1 To provide guidelines for measuring removable alpha and beta radioactivity on equipment and building surfaces.

2.0 RESPONSIBILITIES

2.1 The Site Survey Manager is responsible for assuring this procedure is implemented.

2.2 Survey team members are responsible for following this procedure.

3.0 PROCEDURE

3.1 Equipment and Materials

3.1.1 Smears, Mazlin wipes, filter papers (like Whatman 47 mm dia. glass fiber) or equivalent

3.1.2 Glassine or paper envelopes

3.1.3 Record forms

3.1.4 Counting equipment

3.2 Sample Collection

NOTE: Direct measurements will be completed before a smear sample is taken.

3.2.1 Grasp the smear (filter) paper by the edge, between the thumb and index finger.

3.2.2 Applying moderate pressure with two or three fingers, wipe the numbered side of the paper over approximately 100 cm^2 of the surface.

3.2.3 Place the filter in an envelope.

3.2.4. Record the smear number, site, date, location of the smear, and name of sample collector on the envelope.

3.2.5 Label and secure in accordance with Procedures 3.7 and 3.8. Record pertinent information on the Chain-of-Custody Form.

3.2.6 If the direct measurement was elevated, the smear should be monitored (procedures 2.2 and 2.3) to determine whether contaminated material was transferred to the smear. If an activity level greater than 250 cpm is detected, the smear envelope should be marked as such.

NOTE: Smears having activity levels greater than 2500 cpm should be counted using field instrumentation. Decisions regarding further analyses and method of disposal of contaminated smears will be made by the PM and SSM on a case-by-case basis.

3.3 Field Sample Measurement

3.3.1 If the object of the survey is to determine if radon or thoron daughter products or other short half-life radionuclides are present, the smears should be counted within 1-2 hours before significant decay of short-lived radionuclides has occurred.

3.3.2 If necessary, smears can be counted in the field using portable instrumentation (see Procedure 2.3).

3.3.3 Record count and counting time data on the appropriate record form.

3.3.4 Subtract the background count (determined by counting blank or unused smear) and convert net count to dpm/100 cm^2, using proper time and detector efficiency values.

$$\frac{DPM}{100\,CM^2} = \frac{NETCOUNT}{TIME(\text{MIN}) * EFFICIENCY * \frac{COUNT}{DISINTEGRATION} * \prod_{\pi}^{\Sigma} OTHERMODIFIYINGFACTORS}$$

PROCEDURE 3.8
SAMPLE CHAIN-OF-CUSTODY

1.0 PURPOSE

To provide a method for sample chain-of-custody.

2.0 RESPONSIBILITIES

2.1 The Site Survey Manager is responsible for assuring that this procedure is implemented.

2.2 Survey team members are responsible for following this procedure.

3.0 PROCEDURE

Chain-of-custody is initiated upon collection (or receipt) of samples and continues until samples are transferred to another organization or are disposed. An acceptable chain-of-custody is maintained when the sample is under direct surveillance by the assigned individual; the sample is maintained in a tamper-free container; or the sample is within a controlled-access facility. The chain-of-custody is recorded on a standardized A&A form (see Appendix A) or a form provided by another organization, such as an analytical laboratory or another sampling agency.

3.1 Field Procedures

3.1.1 An individual present during sample collection is designated as the sample custodian and is responsible for maintaining surveillance of the sample until the custody of that sample is transferred to another party. Samples must, at all times, be in the possession and under the direct surveillance of the sample custodian, or secured in a locked vehicle, building, or container. The sample custodian initiates a chain-of-custody form, daily, for all samples collected or received on that day.

3.1.2 Samples may be listed on the form as an individual entry or group of samples having common characteristics and originating from the same site may be recorded as a single entry, provided information describing each sample in the group (e.g. a completed field data form) is attached to or referenced on the custody form.

3.1.3 If sample custody is to be transferred (relinquished), the container and its contents are inspected by the individual accepting custody to assure that tampering has not occurred and custody has therefore been maintained. If evidence of tampering is observed or if any deviations or problems are noted, a notation must be provided on the form by the individual accepting custody. The sample collector must sign the first "Relinquished by" block and the receiver must complete the first "Received by" block.

3.1.4 If sample custody will not be assured under one of the conditions in item 3.0 above, a security seal is placed on the container of the samples. A security seal is a wire, tape, or other such item, which is uniquely identified (numbered), and can be affixed to a package in a manner as to require damaging the seal if the package is opened. Damage to the seal thereby alerts the recipient of a package to the possibility of tampering with the contents. The number of the seal is entered onto the Chain-of-Custody form. Samples, which are under security seals, do not have to be maintained in a secure area; however, precautions should be taken to restrict sample access to authorized individuals.

3.1.5 The original of the chain-of-custody form must contain all signatures and other pertinent records regarding custody. Therefore the original is retained in the possession of the individual who has custody.

3.1.6 As long as samples remain in custody of the sampler, both copies of the chain-of-custody form are to accompany the samples. If custody is transferred to another individual and the control requirements in item 3.0 above are not satisfied, the duplicate copy of the form is packaged with the samples and the original remains with the individual having custody.

3.1.7 Samples collected by other organizations and provided to A&A personnel will have chain-of-custody initiated for them by the individual receiving the samples. When the organization has an established chain-of-custody in place, a copy of the form will be attached to the A&A form.

3.2 Sample Transport

3.2.1 Samples must comply with regulations of the Department of Transportation, if they are to be transported over or through publicly accessible transport routes. The Health and Safety Plan describes the procedure for assuring compliance with this requirement.

3.2.2 Unsealed samples may be transported by a vehicle controlled by the person having custody of the samples, or in that person's hand carried baggage.

3.2.3 Transport by mail, checked baggage, common carrier, or other mode not controlled by the sample custodian of record, requires that security seals be used.

3.2.3 The method of transport is to be identified on the original chain-of-custody record. If inner containers are sealed, additional seals on outer packaging are not required.

3.3 Samples sent to other organizations

3.3.1 The custodian will sign the "Relinquished by" space and the original form will be packed with the samples.

3.3.2 Receiving organizations will be requested to check the container and its contents for signs of tampering and note any deficiencies in the "Comments" portion of the form.

3.3.3 When samples will not be returned to A&A, the receiving organization will be asked to return the original of the form. The form will be provided to the Project Manager, for inclusion with the project records.

3.3.4 If samples will be returned to A& A, the receiving organization will be asked to sign the "Relinquished by" space and pack the form with the samples for return shipment. Upon receipt, the samples and form will be provided to the Project Manager, who will sign the "Received" space and place a copy in the project file.

Appendix B

Eberline Services Oak Ridge Laboratory Quality Assurance Program Manual

Eberline Analytical
Oak Ridge Laboratory
Quality Assurance Program Manual

AUTHORIZATION AND APPROVAL STATEMENT

This **Eberline Analytical** - Oak Ridge Laboratory,
Quality Assurance Program Manual
is authorized and approved in its entirety by:

Saba Arnold Seaver
Quality Assurance Manager

Date: August 1, 2013

Michael R. McDougall
Laboratory Manager

Date: August 1, 2013

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MISSION STATEMENT

Our mission is to ensure that all of The Eberline Services, Oak Ridge Laboratory s-systems, services, processes, and deliverables are of a quality that meets or exceeds client requirements; and to foster a Laboratory culture in which there is a commitment to a rising standard of quality. This culture demands that the quality of those systems, services, processes, and deliverables and the methods used to achieve that quality be continuously improved.

Quality Assurance is a spirit that pervades all aspects of an organization. It is the quality attitude developed by a quality culture in an organization. It is the spirit in which any organization, procedure or activity is documented, implemented and performed. This spirit produces empowerment and motivation in al l employees to achieve the highest level of quality. The result of this attitude is **"Quality Assurance."**

The policy guidelines are presented in this Oak Ridge Laboratory Quality Assurance Program Manual, and are based on the philosophy and premises that:

- People are our greatest asset and are ultimately responsible for the quality of the items and services we provide. Therefore, each person is treated with the greatest possible respect and consideration.
- Employees are inherently proud and want to produce top quality and on time services and deliverables. In order to do this they must be made aware of the quality requirements that are expected and must be provided appropriate facilities, equipment, and proper training.
- A culture of quality embodied within the entire Oak Ridge Laboratory organization is the most effective way to provide support for the employee's commitment to quality.
- Management support is paramount, and organizational responsibilities must ensure integration of quality requirements in the day-to-day operations.
- All systems, services, processes, and deliverables can be planned, performed, assessed, and improved.
- Improvements allow operations to become more efficient and result in contractual requirements performed "on time" and done "right the first time."
- Quality improvements lead to reduced costs and allow the ultimate objective of providing the highest quality items and services to be a viable goal.

Quality is our client s-perception of us. Our actions must assure our clients that the Oak Ridge Laboratory organization provides for quality systems, services, processes, and deliverables that will meet or exceed their requirements. To this end, each employee must understand and exercise the highest standards of ethics in the performance of their duties and ensure the integrity of the data they report.

STATEMENT OF COMPLIANCE AND MATRIX COMPARISON

This Quality Assurance Program Manual addresses the basic requirements outlined in several regulatory manuals, standards, regulations, and national laboratory programs. Matrix comparison to some of these documents is included in the following pages. Additional regulatory requirements are listed in Section 1.0.

NQA-Quality Assurance Requirements for Nuclear Facility Application
National Environmental Laboratory Accreditation Conference (NELAC), USEPA; 2003, the NELAC Institute (TNI), 2009
USEPA Requirements for the Certification of Laboratories Analyzing Drinking Water; 2005
ISO/IEC 17025 for the General Requirements for the Competence of Calibration and Testing
DOE Quality Systems for Analytical Services (QSAS) Document
DoD Quality Systems Manual for Environmental Laboratories (DoD QSM)
PJLA Accreditation Compliance Requirements

This manual is organized as follows:

↑

Name, Title, Authorization and Approval
Table of Contents
Mission Statement
Statement of Compliance and Matrix Comparison
Introduction and Description
Organization and Responsibility
Quality Assurance Objectives
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Control of Process
Preventative Maintenance
Control of Measurement and Test Equipment
Data Reduction, Verification, and Reporting
Document Control
Internal Quality Control
Audits
Quality Assurance and Inspection Records
Corrective Action
Quality Assurance Reports to Management

MATRIX COMPARISON

NQA-1, Cross Reference to - Oak Ridge Laboratory Q.A. Program Manual

NQA-1- Quality Assurance Requirements for Nuclear Facility Applications (*Basic Requirements*)		**Oak Ridge, TN laboratory Quality Assurance Program Manual**	
BASIC RQMT	TITLE	QAM SECT	TITLE
1.	Organization	2.0	Organization and Responsibility
2.	Quality Assurance Program	3.0 4.0	Quality Assurance Objectives Personnel Indoctrination and Training
3.	Design Control	N/A	Does not apply
4.	Procurement Document Control	6.0	Procurement Document Control
5.	Instructions, Procedures, and Drawings	5.0	Instructions and Procedures
6.	Document Control	13.0	Document Control
7.	Control of Purchased Items and Services	7.0	Material Receipt and Control
8.	Identification and Control of Items	8.0	Material Storage and Control
9.	Control of Process	9.0	Control of Process
10.	Inspection	14.0	Internal Quality Control
11.	Test Control	14.0	Internal Quality Control
12.	Control of Measurement and Test Equipment	11.0	Control of Measurement and Test Equipment
13.	Handling, Storage, and Shipping	8.0	Material Storage and Control
14.	Inspection, Test, and Operating Status	14.0	Internal Quality Control
15.	Control of Nonconforming Items	8.0	Material Storage and Control
16.	Corrective Actions	17.0	Corrective Actions
17.	Quality Assurance Records	16.0	Quality Assurance and Inspection Records
18.	Audits	15.0	Audits
	N/A	N/A	Title Page
	N/A	N/A	Authorization and Approval Statement
	N/A	1.0	Introduction and Description
	N/A	10.0	Preventive Maintenance
	N/A	12.0	Data Reduction, Verification, and Reporting
	N/A	18.0	Quality Assurance Reports to Management

MATRIX COMPARISON

10 CFR Part 50, Appendix B Cross Reference to Oak Ridge Laboratory Q.A. Program Manual

NRC 10 CFR Part 50 Appendix B, Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants.		**Oak Ridge, TN Laboratory Quality Assurance Program Manual**	
Criterion No.	TITLE	QAM SECT	TITLE
I	Organization	2.0	Organization and Responsibility
II	Quality Assurance Program	3.0	Quality Assurance Objectives
III	Design Control	N/A	Does not apply
IV	Procurement Document Control	6.0	Procurement Document Control
V	Instructions Procedures, and Drawings	5.0	Instructions and Procedures
VI	Document Control	13.0	Document Control
VII	Control of Purchased Material, Equipment, and Deliverables	7.0	Material Receipt and Control
VIII	Identification and Control of Materials, Parts, and Components	8.0	Material Storage and Control
IX	Control of Special Process	9.0	Control of Process
X	Inspections	14.0	Internal Quality Control
XI	Test Control	14.0	Internal Quality Control
XII	Control of Measuring and Test Equipment	11.0	Control of Measurement and Test Equipment
XIII	Handling, Storage, and Shipping	8.0	Material Storage and Control
XIV	Inspection, Tests, and Operating Status	14,0	Internal Quality Control
XV	Nonconforming Materials, Parts or Components	7.0	Material Receipt and Control
XVI	Corrective Actions	17.0	Corrective Actions
XVII	Quality Assurance Records	16.0	Quality Assurance Inspection Records
XVIII	Audits	15.0	Audits
		N/A	Title Page
		1.0	Introduction and Description
		10.0	Preventative Maintenance
		12.0	Data Reduction, Verification, and Reporting
		18.0	Quality Assurance Reports to Management

MATRIX COMPARISON

DOE Order 414.1**C** Cross Reference to Oak Ridge Laboratory Q.A. Program Manual

DOE Order 414.1 C Quality Assurance			**Oak Ridge, TN Laboratory Quality Assurance Program Manual**
Criterion No.	TITLE	QAM SECT	TITLE
1.	Program	1.0 2.0 3.0 12.0 13.0	Introduction Organization and Responsibility Quality Assurance Objectives Data Reduction, Verification, and Reporting Document Control
2.	Personnel Training and Qualification	4.0	Personnel Indoctrination and Training
3.	Quality Improvement	17.0	Corrective Actions
4.	Documents and Records	16.0 18.0	Quality Assurance Records Quality Assurance Reports to Management
5.	Work Process	5.0 9.0 10.0 14.0	Instructions and Procedures Control of Process Preventive Maintenance Internal Quality Control
6.	Design	N/A	Does not apply
7.	Procurement	6.0 7.0 8.0	Procurement Document Control Material Receipt and Control Material Storage and Control
8.	Inspection and Acceptance Testing	11.0 14.0 15.0	Control of Measurement and Test Equipment Internal Quality Control Audits
9.	Management Assessment	2.0	Organization and Responsibility
10.	Independent Assessment	15.0	Audits
N/A		N/A	Title Page
N/A		N/A	Authorization and Approval Statement

MATRIX COMPARISON

DOE Quality Systems (QSAS). And DoD Quality Systems (QSM) Cross Reference to Oak Ridge Laboratory QA Program Manual.

This cross reference applies also to NELAC Chapter 5.4.2.3

NELAC Chapter 5 Quality Systems		**Oak Ridge, TN Laboratory Quality Assurance Program Manual**	
4.2.6 RQMT	TITLE	QAM SECT	TITLE
	Title Page		Title Page
(a)	Policy statement, objectives, commitment by top management	1.0 3.0	Introduction and Description Quality Assurance Objectives
(b)	Organization and Management structure, Org Charts	2.0	Organization and Responsibility
(c)	Relationship between management, technical operations, support services and the quality system	2.0	Organization and Responsibility
(d)	Document control and records retention	16.0	Quality Assurance & Inspection Records
(e)	Job Descriptions	4.0	Personnel Indoctrination and Training
(f)	Approval signatories, signed concurrences	A&A	Authorization and Approval Statement
(g)	Traceability of measurements	14.0	Internal Quality Control
(h)	List of test methods	9.0	Control of Process
(i)	Review for facility and resource availability	9.0	Control of Process
(j)	Calibration or verification test procedures	5.0	Instructions and Procedures
(k)	Procedures for handling submitted samples	9.0	Control of Process
(l)	Major equipment and measurement standards	9.0 11.0	Control of Process Control of Measurement & Test Equipment
(m)	Calibration, verification, & maintenance	11.0	Control of Measurement & Test Equipment
(n)	Inter laboratory comparison, proficiency testing, reference material, internal Q.C.	14.0	Internal Quality Control
(o)	Corrective actions	17.0	Corrective Actions
(p)	Departures from policy/procedures	5.0	Instructions and Procedures
(q)	Complaints	1.0	Introduction and Description
(r)	Confidentiality and Proprietary rights	1.0	Introduction and Description
(s)	Audits and Data reviews	12.0 15.0	Data Reduction, Verification, and Reporting Audits
(t)	Personnel experience and training	4.0	Personnel Indoctrination and Training
(u)	Ethical and legal responsibilities	1.0	Introduction and Description
(v)	Analytical results reporting	12.0	Data Reduction, Verification, and Reporting
(w)	Table of Contents	TOC	Table of Contents

MATRIX COMPARISON

10 CFR Part 830.122 Cross Reference to Oak Ridge Laboratory Q.A. Program Manual

10CFR 830.122 Quality Assurance Criteria			**Oak Ridge, TN Laboratory Quality Assurance Program Manual**
Criterion No.	TITLE	QAM SECT	TITLE
830.122 (a)	Management/Program	1.0 2.0	Introduction Organization and Responsibility
(b)	Management/Personnel Training and Qualification	4.0	Personnel Indoctrination and Training
(c)	Management/Quality Improvement	3.0 14.0 17.0	Quality Assurance Objectives Internal Quality Control Corrective Actions
(d)	Management/Documents and Records	5.0 9.0 12.0 13.0 16.0 18.0	Instructions and Procedures Control of Process Data Reduction, Verification, and Reporting Document Control Quality Assurance Records Quality Assurance Reports to Management
(e)	Performance/Work Process	7.0 8.0 10.0 14.0	Material Receipt and Control Material Storage and Control Preventive Maintenance Internal Quality Control
(f)	Performance/Design	N/A	Does not apply
(g)	Performance/Procurement	6.0	Procurement Document Control
(h)	Performance/Inspection and Acceptance Testing	11.0 14.0 15.0	Control of Measurement and Test Equipment Internal Quality Control Audits
(i)	Assessment/Management Assessment	2.0	Organization and Responsibility
(j)	Assessment/Independent Assessment	2.0 15.0	Organization and Responsibility Audits
N/A		N/A	Title Page
N/A		N/A	Authorization and Approval Statement

MATRIX COMPARISON

EPA SW-846 Cross Reference to - Oak Ridge Laboratory Q.A. Program Manual

EPA SW-846 (Essential Elements)		**Oak Ridge, TN Laboratory Quality Assurance Program Manual**	
BASIC RQMT	TITLE	QAM SECT	TITLE
1.	Title Page	N/A	Title Page
2.	Table of Contents	N/A	Table of Contents
3.	Project Description	1.0	Introduction and Description
4.	Project Organization and Responsibility	2.0	Organization and Responsibility
5.	Q.A. Objectives	3.0	Quality Assurance Objectives
6.	Sampling Procedures	N/A	Does not apply to laboratory
7.	Sample Custody	9.0	Control of Process
8.	Calibration Procedures and Frequency	11.0	Control of Measurement and Test Equipment
9.	Analytical Procedures	5.0 9.0	Instructions and Procedures Control of Process
10.	Data Reduction, Validation, and Reporting	12.0	Data Reduction, Verification, and Reporting
11.	Internal Quality Control Checks	14.0	Internal Quality Control
12.	Performance and System Audits	15.0	Audits
13.	Preventive Maintenance	10.0	Preventive Maintenance
14.	Specific Routine Procedures Used to Assess Data Precision, Accuracy, and Completion	14.0	Internal Quality Control
15.	Corrective Action	17.0	Corrective Actions
16.	Quality Assurance Reports to Management	18.0	Quality Assurance Reports to Management
N/A		N/A	Authorization and Approval Statement
N/A		4.0	Personnel Indoctrination and Training
N/A		6.0	Procurement Document Control
N/A		7.0	Material Receipt and Control
N/A		8.0	Material Storage and Control
N/A		13.0	Document Control
N/A		16.0	Quality Assurance and Inspection Records

MATRIX COMPARISON

EPA QA/R-5 EPA Requirements for Quality Assurance Project Plans

EPA QA/R-5, EPA Requirements for Quality Assurance Project Plans		Oak Ridge, TN Laboratory Quality Assurance Program Manual	
RQMT	**TITLE**	**SECT**	**TITLE**
A	**Project Management**		
A1	Title and Approval Sheet		Title Page Authorization and Approval (A&A) Statement
A2	Table of Contents		Table of Contents Page Headers (document control)
A3	Distribution List		Title Page
A4	Project/Task Organization	1.4 2.1 2.2 2.5	Introduction Organizational Structure Responsibility Organization Charts
A5	Problem Definition/Background	3.0 9.0 14.0	Quality Assurance Objectives Control of Process Internal Quality Control
A6	Project/Task Description	9.0	Control of Process
A7	Quality Objectives and Criteria	3.0	Quality Assurance Objectives
A8	Special Training/Certification	4.0	Personnel Indoctrination and Training
A9	Documents and Records	5.0 9.2 13.0 16.0	Instructions and Procedures Documented Procedures Document Control Quality Assurance and Inspection Records
B	**Data Generation and Acquisition**		
B1	Sampling Process Design (Experimental Design)	N/A	
B2	Sampling Methods	N/A	
B3	Sample Handling and Custody	14.4	Sample Custody
B4	Analytical Methods	5.0 9.0	Instructions and Procedures Control of Process
B5	Quality Control	14.0	Internal Quality Control
B6	Instrument/Equipment Testing, Inspection, and Maintenance	10.0 11.0	Preventive Maintenance Control of Measurement and Test Equipment
B7	Instrument/Equipment Calibration and Frequency	11.0	Control of Measurement and Test Equipment
B8	Inspection/Acceptance of Supplies and Consumables	7.0 8.0	Material Receipt and Control Material Storage and Control
B9	Non-direct Measurements	10.0	Data Reduction, Verification, and Reporting
B10	Data Management	10.0	Data Reduction, Verification, and Reporting
C	**Assessment and Oversight**		
C1	Assessments and Response Actions	15.0 17.0	Audits Corrective Action
C2	Reports to Management	18.0	Quality Assurance Reports to Management
D	**Data Validation and Usability**		
	Data Review, Verification, and Validation	12.0	Data Reduction, Verification, and Reporting

EPA QA/R-5, EPA Requirements for Quality Assurance Project Plans		Oak Ridge, TN Laboratory Quality Assurance Program Manual	
RQMT	**TITLE**	**SECT**	**TITLE**
D1		14.3	Data Verification
D2	Verification and Validation Methods	12.0	Data Reduction, Verification, and Reporting
D3	Reconciliation with User Requirements	12.0	Data Reduction, Verification, and Reporting

1.0 INTRODUCTION AND DESCRIPTION

1.1 PREFACE

Eberline Services ‼ Oak Ridge Laboratory is a radiochemistry laboratory that specializes in providing services for radiological assays to the environmental industry. Radionuclides are quantified within materials such as surface water, ground water, drinking water, wastewater, soil, sediment, sludge, vegetation, and hazardous waste. Bioassay (urine) analysis is performed for total uranium. The objective of the laboratory is to produce the highest quality data that are accurate, precise, legally defensible, and meet our clients data needs and requirements in a timely and cost effective manner.

The management of Eberline Services, Oak Ridge Laboratory is committed to a rigorous Quality Assurance (Q.A.) Program. While this commitment is necessary for the normal conduct of business, our basic policies dictate the highest standards of ethics and integrity in the conduct of our affairs. This philosophy and the specific procedures to attain policy objectives fromthe framework of our Q.A. Program. We will provide only those services that are within our qualifications and with confidence tha t our Q.A. Program and all related operating procedures dictate reliable performance of those services.

1.2 PURPOSE

This manual outlines management's Q.A. policy and establishes a requirement that procedures be promulgated and implemented to accomplish all of the quality assurance elements necessary to fulfill our responsibility to meet or exceed client or regulatory specifications. It also provides a means for creating mutual understanding regarding our Q.A. program and reliability techniques with our subcontr actors, suppliers, and clients. This Eberline Services -Oak Ridge Laboratory Quality Assurance Program provides the structure, policies and responsibilities for the execution of quality control and quality assessment operations to assure that the laboratory meets defined standards of quality.

1.3 SCOPE

This Quality Assurance Program Manual provides guidance to meet operational Q.A. requirements.

In addition to the documents identified in the Cross Reference Section, this Manual complies with applicable requirements of the following the latest revisions of regulations below:

1.3.1 NRC 10 CFR Part 21, "Reporting of Defects and Non-compliance."

1.3.2 ANSI/ANS-10.3-, "Documentation of Computer Software.

1.3.3 NRC Regulatory Guide 4.15, Rev. 1, "Quality Assurance for Radiological Monitoring Programs - Effluent Streams and the Environment."

1.3.4 U.S. EPA QA/R-5, "EPA Requirements for Quality Assurance Program Plans."

1.3.5 DOE Order 414.1C Quality Assurance.

1.3.6 ISO/IEC 17025, "General Requirements for the Competence of Calibration and Testing Laboratories."

1.3.7 USEPA Directive 2185, Good Automated Laboratory Practices (GALP).

1.3.8 DOE Quality Systems for Analytical Services (QSAS)

1.3.9 DoD Quality Systems Manual for Environmental Laboratories (DoD QSM)

1.3.10 A National Environmental Laboratory Accreditation Conference (NELAC) Chapter 5 Quality Systems , July 2003.

1.3.11 USEPA Manual for the Certification of Laboratories Analyzing Drinking Water, EPA 815 - R-004, January 2005.

1.4 INTRODUCTION

Quality assurance, as outlined herein, is a tool that allows management to util ize the expertise and experience of all personnel on the job. It requires each worker to be aware of his/her work environment and to continually evaluate methods and processes to ensure that the best and correct operation is being performed. It requests ea ch employee to identify and suggest any improvement to the processes while performing an operation. Improvements or changes shall be coordinated with management who will validate improvement and disseminate the information to all affected personnel. Manage ment shall also, as needed, change procedures and provide additional training. This program also requires that all personnel be qualified, and trained on a continuing basis to maintain that qualification and be assimilated into the Oak Ridge Laboratory quality culture.

Management will provide resources, tools, equipment, scheduling, and training to ensure personnel can perform their duties effectively.

1.4.1 Management will also ensure that internal assessments are performed annually to evaluate management and p rocesses with feedback for review with a goal of improving all areas of operations.

1.4.2 It is only by having a quality assurance culture, with all personnel involved, that a system, service, or product can be provided with full assurance that the best possible work, the best possible product, or the best possible service has been provided.

1.4.3 In order to ensure that this manual is an effective management tool, subjects that are not normally considered quality assurance, i.e. safety, security, etc., are addressed in other management documents.

1.4.4 The following titled designations of positions are used within the Oak Ridge, TN Laboratory:

Laboratory Manager: Refers to the General Manager of the Oak Ridge Laboratory.

Radiation Safety Officer (RSO): Refers to the RSO of the Oak Ridge Laboratory.

Emergency Coordinator: Refers to the individual who is responsible for overseeing and directing activities and protocols associated with emergencies and disasters.

Project Manager: Refers to an individual who is responsible for client service activities and is the single point of contact with a client for the laboratory.

Supervisor: Refers to individuals within the laboratory who are responsible for the operational functions of a group of personnel.

Q.A. Manager: Refers to the individual who is responsible for the Laboratory s Q.A.

Program.

1.5 DESCRIPTION

This document outlines the organization of the Q.A. functions within the laboratory. It depicts the lines of authority, and lists the duties and responsibilities within th e organization. It provides direction for the preparation of Procedures Manuals, which provide the detailed methods of processes and analyses that accomplish the goal of quality data in terms of precision, accuracy and reproducibility.

1.6 CONFIDENTIAL AND PROPRIETARY INFORMATION

Oak Ridge Laboratory employees are exposed to confidential and/or proprietary information pertaining to the company and its clients. Information concerning the report of analysis, radiation dosimetry records, audit reports, calibration reports, and other documents relating to a project are considered confidential. This information is to be released only to the client or to the client's authorized representative. Each employee will sign an agreement with the Oak Ridge, TN Laboratory concerning the security of proprietary and confidential information. A copy of the agreement will be retained in the employee's personnel file (at the corporate office in Albuquerque, NM).

1.7 TECHNICAL COMPLAINTS

Technical complaints will be addressed b y the Laboratory Manager, Project Manager, Quality Assurance Manager, or staff member with expertise in the area of complaint. If the complaint is not valid, every attempt will be made to satisfy the client. If the complaint is determined to be valid, the cause of the complaint shall be identified and corrected as soon as feasible. Verification that the cause for a valid complaint has been corrected is the responsibility of the individual addressing the complaint. Details of all technical complaints shall b e recorded and maintained in the customer's project file. Clients are also encouraged to provide feedback on the Eberline Analytical website via a statement on each client report.

1.8 ETHICAL AND LEGAL RESPONSIBILITIES

Eberline Services-Oak Ridge Laborato ry utilizes a clearly stated ethics policy that is discussed with all new employees during orientation. Each employee is required to understand the high standards of ethics and integrity required in order to perform their duties and to ensure the integrity of the data reported in connection with their employment at the Oak Ridge Laboratory. Each employee will understand that intentionally reporting data that are not the actual values obtained, intentionally reporting dates and/or times or data analyses that are not the actual dates and/or times of analyses, intentionally representing another individuals work as their own; or any other action that may affect the integrity of the data reported by the laboratory; will be the cause for dismissal.

1.9 ACCREDITATIONS

Through applications, pre-qualification, performance testing, and external auditing programs; the laboratory has been granted certification by different agencies, organizations, and states. The Laboratory maintains proficiency as required by the cli ents and regulatory certifying agency. The Quality Assurance Manager maintains credentials and lists of certifying agencies. The list of certifications maintained by the Oak Ridge Laboratory includes:

State of Tennessee, Department of Health – Laboratory Division
State of California, Department of Public Health – ELAP Branch
State of South Carolina, Dept of Health & Environmental Control, Environmental Lab Certification Program

State of Utah, Department of Health Bureau of Laboratory Improvement
State of New Jersey, Department of Environmental Protection, Office of Quality Assurance
State of New York, Department of Health, Environmental Lab Approval Program
State of North Dakota, Dept. of Health Environ. Lab. Certification Program- Chemistry Division
State of Nevada, Dept. of Conservation Bureau of water Quality EnvironmentalLab Services
State of Louisiana, Department of Environmental Quality
State of Texas, Texas Commission of Environmental Quality
State of Alabama, Department of Environmental Management
Commonwealth of Virginia, Dept. of General Services Division of Consolidated Lab Services
State of Washington, Department of Ecology**Perry Johnson Laboratory Accreditation, Inc.**
Department of Energy (DOE)
Department of Defense (DoD)

2.0 ORGANIZATION AND RESPONSIBILITY

2.1 ORGANIZATIONAL STRUCTURE

The Laboratory Manager has overall responsibility for this Quality Assurance Program (hereafter referred to as the Program). In this capacity, he has delegated the responsibility for formulation, implementation, and execution of the Program to the Laboratory Q.A. Manager.

Current organizational charts, identifying key individuals and the structure of the laboratory, are included in the "Statement of Qua lifications." Additional organizational structure, functional responsibilities, levels of authority, and lines of communication for management, direction, and execution of the Program are documented below.

2.2 RESPONSIBILITY

Laboratory Management will periodically assess the integrated quality assurance program, its performance, and its effectiveness. Problems that hinder the organization from achieving its objectives will be identified and corrected.

Management will provide training and qualification to ensure quality products and services. Every employee is responsible for supporting the QA program po licies, procedures, a nd guidance with each employee being responsible for their work . Professional qualifications and experience of all individuals and positions are maintained. Position descriptions and resumes are kept on file in the QA office. The specific duties of selected personnel are described below. Other job descriptions are locat ed within an employee s training file in the QA office.

2.2.1 Laboratory Manager

The Laboratory Manager, under the authority of the President of Eberline Analytical Corporation, is responsible for the overall laboratory productivity and optimization of the efforts of the analytical staff and those who directly support the analytical effort. Staff interacts with the Lab Manager throughout the day. The Laboratory Manager is responsible for the implementation of regulatory standards, and national program requi rements (NELAP, TNI, DOE, and Do D). The Laboratory Manager is responsible for the all safety aspects of the laboratory operations

The duties of the Laboratory Manager include the following.

- § Overall direction and general administration.
- § Daily operation of the laboratory.
- § Review of analytical procedures and practices.
- § Recruitment, hiring, assignment, evaluation and termination of personnel.
- § Training and professional development of staff.
- § Review of proposals, bids, pricing and quotations.
- § Perform an annual assessment of the laboratory operation.

2.2.2 Quality Assurance Manager

The Quality Assurance Manager operates independently from line management while reporting to the Laboratory Manager. The QA Manager has sufficient authority and organizational freedom to identify quality problems, to initiate, recommend or provide solutions; to verify implementation o f solutions, and if necessary, to stop work until the problem is resolved. The QA Manager has independence from cost scheduling, and production considerations . In his capacity, he has the authority to control processing, delivery, installation, or use of i tems o r services until proper disposition of an identified non-conformance, deficiency, or condition adverse to quality. The QA

Manager has a direct line of communication to the President of Eberline Analytical Corporation for matters of quality.

The duties and responsibilities of the QA Manager are as follows.

- § Develop QA procedures, instructions and plans.
- § Maintain surveillance over all applications of the QA P rogram; make recommendations for resolution of problems, or further evaluation by management.
- § Monitor external audits, write responses, and ensure corrective actions.
- § Issue non-conformances and formal corrective action(s).
- § Issue stop-work orders for work that is not in compliance with requirements.
- § Direct, and maintain records of analytical performance evaluation programs to ensure full and prompt participation and evaluation of results and derivation of all benefits relating there from.
- § Direct, and maintain records of laboratory certification programs.
- § Authorized to sign and designate other personnel to sign client related Certificates of conformance and/or non-conformance.
- § Ensures compliance with Regulatory Standards and National Program requirements (e.g. NELAP, TNI, DOE, DoD, . . .)

2.2.3 Health and Safety Manager

The Health and Safety Manager reports directly to the Laboratory Manager and oversees the daily implementation of the laboratory s health and safety program. The program includes an integrated chemical hygiene plan, safety orientation and training, radiation safety plans and training, sample disposal and shipment, and safety checks and audits.

- § The duties and responsibilities of the Health and Safety Manager are as follows.
- § Administer chemical hygiene, safety, fire extinguisher, etc. training.
- § Management of sample disposal in conformance with the waste disposal policy.
- § Packaging and shipment of samples, or designation thereof, following DOT regulations.
- § Maintain Material Safety Data Sheet (MSDS) documentation.
- § Direct spill response.
- § Direct safety checks and audits.
- § Ensures compliance with regulatory standards and national program requirements (NELAP, TNI, DoD, DOE, . . .)

2.2.4 Technical Director

The Technical Director reports directly to the Laboratory Manager and provides technical direction or advice for the laboratory operations and/orspecial programs, projects, or activities.

- § The duties and responsibilities of the Technical Director are as follows.
- § Perform technical analysis for specific projects.
- § Make recommendations for research and development.
- § Write technical manuals.
- § Design systems, procedures, and documentation as necessary.
- § Assist chemistry supervisors and technicians in technical interpretation of program requirements.
- § Consult with clients, make recommendations regarding analytical schemes.

2.2.5 Data Review Department Staff

The Data Review Department has been structured to handle the specific project requirements of

our clients. The Department is responsible for producing quality control (QC) reports, for ensuring proper assembly of data packages and production of electronic data deliverables (EDDs) that meet the requests of the clients. Data Review personnel, in concert with the QA Manager, will assess the requirements of the various programs and client specific requirements, then interact with the appropriate laboratory personnel to ensure compliance with the client's statement of work. These efforts improve the accuracy and efficiency with which QC reports and data packages are prepared and forwarded to the client. Data deliverables are those items associated with the analyses of samples that are provided to the client.

Data Review staff responsibilities include the following.

- § Assuring that analytical data have been correctly entered in the final report.
- § Assuring that data are not released without reviews.
- § Assuring that all data are released to the correct contact person.
- § Producing QC reports.
- § Assembling Data Packages.
- § Ensuring that submitted EDD are complete, verified and in appropriate format.

2.3 ASSESSMENT

2.3.1 The Laboratory Manager will perform routine and continuous assessment of the management system to identify, correct, and prevent management problems that hinder achievement of the organization's objective. The assessment will focus on broad categories of management issues to determine the effectiveness of the integrated managementsystem.

2.3.2 Laboratory Manager's assessments will not be conducted to verify conformance to regulations, product standards, or established procedures, but will evaluate customer and employee perceptions relative to the following key issues.

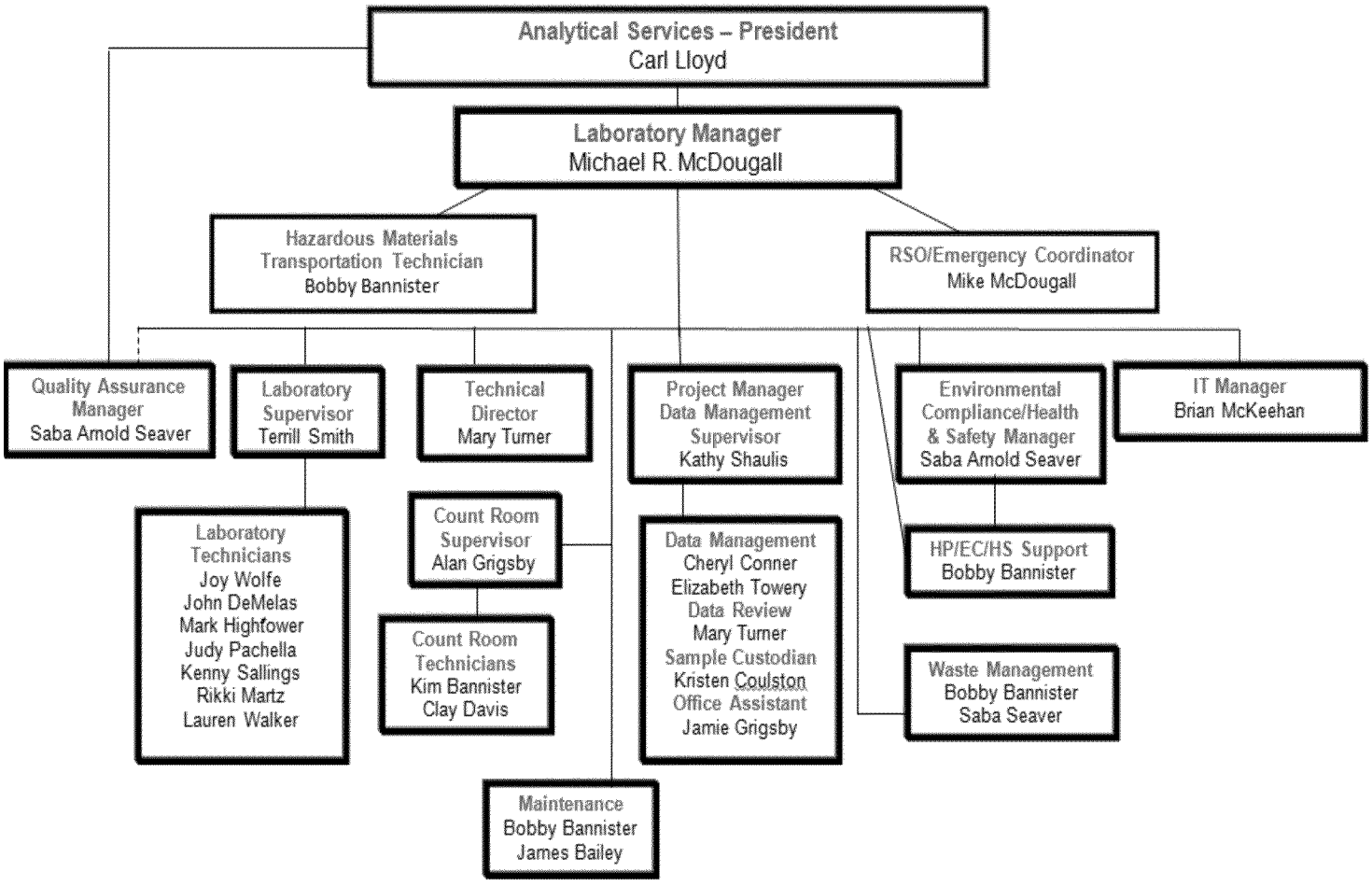
- § Mission and strategic objectives of the organization.
- § Employees' role in the organization.
- § Customers' expectations and degree to which expectations are being met.
- § Opportunities for improving quality and cost effectiveness.
- § Recognizing and enhancing human resource capabilities.

2.3.3 Results of the Laboratory Manager's management assessment and recommendations will be documented annually. Decisions and related actions resulting from the recommendations will be properly followed up and evaluated for their effectiveness. Moreover, the opportunity for customer feedback is afforded by means of an on-line customer feedback/satisfaction survey on the laboratory website.

2.4 ORGANIZATION CHARTS

2.4.1 The Oak Ridge Laboratory Organization is illustrated in Figure 2.1

Figure 2.1
Oak Ridge, TN Laboratory Organization



3.0 QUALITY ASSURANCE OBJECTIVES

3.1 OBJECTIVES

The Oak Ridge Laboratory Q.A. Program is organized to meet the following objectives.

3.1.1 To ensure performance of those actions that provide confidence that quality isachieved.

3.1.2 To provide an effective control for the verification of characteristics of all systems, services, and processes that produce data of the required quality.

3.1.3 To ensure that systems, services, processes, and deliverables meet the rigid quality and reliability standards of the Oak Ridge Laboratory. Also, to ensure that individual client criteria pursuant to these standards are met.

3.1.4 To provide a continuing monitoring service for review of operating procedures, and for overall effectiveness and evaluation of the Q.A. Program. Also, to provide observations and recommendations for improvement in all areas of laboratory operations where quality may be affected.

3.1.5 To ensure the program provides valid records of the control measures applied to all factors bearing on the result of investigations.

3.1.6 To ensure the assessment of results provides feedback to improve the process.

3.1.7 To foster a culture of commitment to achieve a rising standard of quality that demands that the methods utilized to achieve the quality systems, services, processes, and deliverables be continuously monitored and improved.

3.2 QUALITY IMPROVEMENT

Operational processes will be reviewed continually by management and employees to detect and prevent problems and to ensure quality improvement. Any item or process that does not meet established requirements will be identified, controlled, and corrected. The cause of problems will be identified with corrections made to prevent recurrence. Item reliability, process implementation, and quality-related information will be reviewed and the data analyzed to identify items and processes needing improvement.

3.3 RESPONSIBILITIES

Employees are an integral part of the organization and are responsible to be aware of their work environment, to review operational processes and materials utilized, to identify any problems, and to make suggestions and recommendations for improvement. Employees are empowered to make and/or recommend corrections to improve operations and to prevent recurrence of the problems. Employees are also empowered, through their supervisor, to stop work where detrimental ethical, contractual, quality, safety, or health conditions exist. Management will immediately be made aware of any situations requiring work stoppage.

All employees are responsible for s upporting the Program in principle and in detail and shall retain responsibility for the quality of their work.

Management is responsible to be actively involved in the quality improvement process to ensure

proper focus is maintained and for resolution of difficult issues. Management will maintain a no fault attitude to encourage employees to identify problems that compromise safety and reliability. Management will consider all recommendations for quality improvement and will recognize employee contributions.

3.4 CORRECTIONS

Items and processes that do not meet established requirements must be identified, documented, analyzed, and resolved. Corrective actions will be implemented and followed up to ensure effectiveness.

No laboratory analytical data will be revised or corrected after reporting to clients without full documentation of the process. The documentation must show: a) what necessitated the change; b) details of the change in terms of re -run records or recalculation; c) approval process for the change; d) formal client notification.

4.0 PERSONNEL QUALIFICATION AND TRAINING

4.1 QUALIFIED PERSONNEL

4.1.1 The Oak Ridge Laboratory personnel who perform activities that affect quality will have education, experience and training to ensure that suitable proficiency is achieved and maintained. A job description, identifying position qualification and duty requirements, will be included in each individual's training records.

4.1.2 All personnel will have training outlining their ethical and legal responsibilities, including th e potential punishment and penalties for improper, unethical, or illegal actions.

4.1.3 Personnel performing technical functions or processes will have known and documented related work experience and minimum qualifications of education.

4.2 RESPONSIBILITY

4.2.1 Supervisors are responsible for initial evaluation of capabilities and qualifications of assigned personnel and will assign those personnel to perform functions based on the individual's qualifications and abilities.

4.2.2 Supervisors and managers are responsible for the day-to-day monitoring of assigned personnel for evidence of unethical, improper, or illegal activities.

4.2.3 Appropriate training is the responsibility of the supervisors with support from management. Training will address specific needs and will vary accord ing to each job's requirements and previous experience of the employee, and will ensure:

4.2.3.1 Understanding of the fundamentals of the work and its context,

4.2.3.2 Understanding of the processes and tools being used, the extent and sources of variability in those processes and tools, and the degree to which control over the variability is maintained,

4.2.3.3 Emphasis on correct performance of the work, understanding why quality requirements exist, and potential consequences of improper work, and

4.2.3.4 Emphasis on "doing it right the first time. A particular emphasis is placed on employee safety.

4.2.4 Management will provide ALL employees the resources, tools, equipment, scheduling, and structured training to ensure personnel can perform their duties effectively. New employees will receive detailed information concerning the general corporate policies and the specific laboratory safety practices, and security policies. Training shall be conducted on an individual basis to achieve and maintain suitable proficiencies. The training will include, but will not be limited to:

- Ethical and Legal responsibilities
- Health and Safety
- Radiation Protection
- Waste Management
- Quality Assurance
- Laboratory Procedures
- LIMS Operation

4.2.5 Access to all laboratory documents and procedures will be available at all times to all employees who will be expected to familiarize themselves with these documents.

4.2.6 Milestone achievements or unique training will be noted by the supervisors via entry in the training records. Available certificates of traini ng, education, or awards will also be maintained with the individual's training records.

4.2.7 Supervisors will monitor individual work habits to ensure proficiency is maintained, to note progressive improvement, and to identify any needed supportive training. Additional training requirements will be developed by the individual's supervisor.

4.2.8 As needed, employees will be informed of the requirements of special clients/programs necessary to achieve their duties and responsibilities. Familiarization will be made a matter of record.

4.2.9 All personnel training records will be maintained in the QA office. The details for maintenance of training requirements and records are outlined in the Oak Ridge Laboratory Management Procedure, MP-042 Personnel Training."

5.0 INSTRUCTIONS AND PROCEDURES

5.1 POLICY

The Oak Ridge Laboratory policy uses written and approved procedures for routine activities and for analytical and operational processes. Applicable Laboratory procedures are available to all personnel. The most current revision of the appropriate procedure will be maintained and documented on the laboratory computer server. Departures from routine procedures due to non-standard situations or specific requests from clients will be approved by management and fully documented.

In addition to analytical procedures (AP) the laboratory maintains Management Procedures (MP) that describe the policy and approach for performing quality functions. Separate procedures for Health and Safety, Radiation Protection and Waste Management, are also maintained.

5.1.1 ANALYTICAL PROCEDURES

Analytical procedures are descriptions of particular protocols for testing or operations. Analytical procedures will be developed based on published reference procedures for each test or process, and authorized for use by the Laboratory Manager.

5.1.2 Qualification requirements for personnel performing operations and criteria used to determine the proficiency of the operator will be documented.

5.1.3 Each technical procedure will include a list of Personal Protective Equipment (PPE) required for the operation being performed. Training for the identification, operation, use, limitations, and disposal of the PPE will be conducted.

5.1.4 Each technical procedure will identify any chemicals/reagents required for completion of the operation. Material Safety Data Sheets (MSDSs) for those chemicals/reagents will be readily available, and training applicable to the MSDSs will be conducted.

5.1.5 Training will be conducted to the procedures used for processing wastes generated within the appropriate chemistry laboratory.

5.2 PROCEDURE MANUALS

Procedure manuals consist of the individual analytical procedures for a laboratory area or for an operation combined into one document. The procedures within the manual define all parameters of the operations being performed to include required accuracy and completeness of specific measurement parameters involved. Procedures will be incorporated into procedure manuals. Signature on the Authorization and Approval page applies to all procedures in the manual.

5.3 FORMAT AND DISTRIBUTION

5.3.1 Procedures will comply with the format prescribed in the laboratory management procedure (MP-021, Preparation of Technical and Project QA Documents) and will be approved by the QA Manager and the Laboratory Manager.

5.3.2 Employee access to the most current revision of procedures and manuals will be through the Laboratory computer server. Any distribution of controlled copies of any Laboratory procedure will be in accordance with the laboratory's document control protocol.

5.3.3 The Laboratory Manager is responsible for the maintenance and security of the original electronic version of all laboratory procedures and manuals and for ensuring that the most current revision of the procedures and manuals are promptly posted and accessible to all employees.

5.4 REVIEW

Laboratory technical procedure, manuals and Quality Assurance Plan wil l be reviewed annually and whenever program or procedural changes occur with updates as appropriate. Such reviews will be documented. All effected laboratory personnel and document holders will be made aware of any changes. Training of laboratory personnel on new changes will be conducted as necessary.

5.5 REVISION

5.5.1 The appropriate supervisor, or designated representative, is responsible for revisions or changes to the applicable procedure manuals.

5.5.2 Revisions are reviewed and approved by the organization(s) and personnel responsible for the original document. When possible, revisions or changes will be accomplished on a page replacement basis.

5.5.3 The Q.A. Manager will be advised of any changes in procedures required to satisfy specifications of the client.

5.5.4 The final revision shall be reviewed, approved, and authorized by the laboratory manager and QA manager. The electronic copy is placed on the laboratory server for access.

5.5.5 The Q.A. Manager will be responsible for the electronic retention of past revised and superseded procedures. The Q.A. Manager will also be responsible for maintaining the server location where current revisions are stored for employee reference.

6.0 PROCUREMENT DOCUMENT CONTROL

6.1 PURCHASING

Procurement of material, components, supplies, reagents, equipment, and services necessary to carry on the business interests of the Oak Ridge Laboratory is initiated by purchase requisition and controlled by the use of an authorized purchase order number. To the extent necessary, purchase orders will require suppliers to have a Q.A. program consistent with the requirements of this document. Detailed information on procurement is outlined in the laboratory's Purchasing Procedure.

6.2 PURCHASE REQUISITION REVIEW

Purchase requisitions or change orders are reviewed by purchasing department personnel to ensure conformance to the procurement requirements. As applicable, quality related requisitions are reviewed by Q.A. personnel prior to being processed. Change orders undergo the same review process.

6.3 CERTIFICATION/CERTIFICATE OF CONFORMANCE

All materials and processes requiring certification and certificates of conformance are identified on the face of the purchase requisition. Adequate information is provided to ensure supplier compliance to the required specifications. The Q.A. Manager is responsible for the retention, filing, and recall of material certification or certificates of conformance.

6.4 SUBCONTRACTS

When subcontracting analytical work, Oak Ridge Laboratory Management will ensure that the subcontractor can meet all the technical specification, maintain the appropriate certification (NELAP, DOE, DoD, State, . .) and that the prospective subcontractor has a QA program consistent with the requirements of this document. The Oak Ridge Management will secure the client approval for subcontracting their analytical work prior to commencement of the subcontract. The Q.A. Manager is responsible for evaluation and acceptance of the subcontractor's Q.A. program.

6.5 VENDORS

6.5.1 For procurement of quality-related items or services, the Q.A. Manager is responsible for vendor evaluation and approval. Analytical service vendor evaluation and qualification will be through accreditation as a secondary standard calibration laboratory (NVLAP, NIST); an audit by Oak Ridge Laboratory personnel or an acceptable audit agency; or facility inspection, test reports, or receipt inspections, when the quality of the materials or service can be verified by these methods. Documentary evidence that products and services conform to procurement requirements will be provided and retained. A list of approved vendors will be maintained by the Procurement Office.

6.5.2 The effectiveness of the control of quality by contractors and subcontractors will be assessed at intervals consistent with the importance, complexity, and quantity of the product or services.

6.5.3 The purchasing department is responsible for maintaining a record of quality related materials received from vendors including any reports for non-conforming material.

6.6 QUALITY RELATED SERVICES

Q.A. personnel will review the purchase requisitions for quality related services. Those services that are determined to be quality related will include, as applicable, a statement, or wording, in the body of the purchase order or by attachment identifying the applicable requirement.

7.0 MATERIAL RECEIPT AND CONTROL

7.1 POLICY

Only material components, supplies, reagents or standards with acceptable quality characteristics and from qualified vendors will be allowed into the laboratory.

7.2 RESPONSIBILITY

Receipt and initial verification of all materials and equipment received by the Oak Ridge Laboratory, either purchased or contract (client) supplied, is the responsibility of the receiving or designated individual. Technical verification for materials and equipment will be pe rformed by the requisitioner or Q.A. Manager, whichever is applicable. Quality related purchase order items will be receipt inspected by Q.A. personnel.

7.3 MATERIAL CONTROL

Purchased material is controlled by the Laboratory Supervisor or designated individual.

7.3.1 The receiving and stock control clerk, or designated individual, is responsible for the expedient and correct routing of all initially accepted received materials to stock, or to the requisitioner.

7.3.2 Purchasing department personnel are responsible for maintaining a rec ord of materials received from v endors, includ ing Rejected Material Report or equivalent form, for any non -conforming material.

7.4 NON-CONFORMING MATERIAL

When received material, affecting quality, has been determined to be non -conforming, the requisitioner will work with the purchasing agent and will be responsible for proper processing.

7.5 RECORDS

Records of receipt of services and supplies that affect the quality of laboratory operation willbe identified with date of receipt, expiration date, source, lot or serial identifier, and calibration or certification records as appropriate.

8.0 MATERIAL STORAGE AND CONTROL

8.1 POLICY

All materials and supplies in storage will have the necessary protection to preclude deterioration, corrosion, or damage during storage life and will carry identification sufficiently clear to ensure that only those materials specified by process instructions will be withdrawn from material storage and issued for processing.

Only analytical grade chemicals and reagents, bearing such grade identification will be utilized by the Laboratory. Each container will be assigned a unique identification number upon receipt. The date of receipt will be posted on each container. The use and the retention (shelf life) of such chemical will be monitored by the Laboratory Supervisor.

All standards used by the Laboratory must be NIST certified. Each standard must be accompanied with a certificate showing the name, composition, concentration, reference number and NIST Certification. The use and distribution of these standards will be monitored by the LIMS. The certificate and certification documents of standards will be controlled by the QA department.

8.2 RESPONSIBILITY

Only authorized personnel will have access to, and the responsibility for, control and issue of materials or supplies. Materials and supplies will be stored to allow for ready identification. Care will be taken to preclude mixing of rejected material and supplies with those that are qualified for issue.

9.0 CONTROL OF PROCESS

9.1 STANDARD PRACTICES

Standard practices applicable to services provided by the Oak Ridge Laboratory are contained in documented procedures and this Q.A. Program Manual. Every effort is made to implement and fulfill the requirements of Federal and local laws, rules, guidance(s), and directives as may be applicable to the operational practices within the Oak Ridge Laboratory. These may include but are not limited to:

9.1.1 Federal and State rules and regulations.

9.1.2 Consensus standards related to the services performed (e.g., American National Standards Institute).

9.1.3 Regulatory Guides published by the Nuclear Regulatory Commission, Department of Energy, the Environmental Protection Agency, and the Department of Defense.

9.1.4 Specific contractual agreements with clients.

9.1.5 Where conflicts may occur among any of the above items, the client will be notified and requested to specify the practice to be followed.

9.2 DOCUMENTED PROCEDURES

Routine analytical operating procedures are documented. Each laboratory procedure includes quality control criteria that are applicable to that process. The laboratory management will develop, promulgate, and implement procedures that document the operations performed in the laboratory. Additionally, the following general pr ocedures or documents, as applicable, will be developed:

9.2.1 Quality Assurance Procedures

9.2.2 Radiation Safety Manual and Procedures

9.2.3 Sample Control Procedures

9.2.4 Purchasing Policies and Procedures

9.2.5 Data Review Procedures

9.2.6 Environmental Compliance Procedures

9.2.7 Safety Procedures

9.2.8 Chemical Hygiene Plan

9.2.9 Hazard Communications Program

9.2.10 LIMS Procedures

9.2.11 Management Procedures

9.2.12 Analytical Procedures

9.3 RESPONSIBILITY

The Laboratory Manager, or designated representative, determines which instructions or procedures require quantitativ e or qualitative acceptance criteria and specify the appropriate criteria on special contracts or projects.

9.4 WORK POLICY

All work to be performed by the Oak Ridge Laboratory on client samples is authorized by the client and controlled through a Laboratory I nformation Management System (LIMS) work order document which incorporates the client's requirements. (Or by some other document deemed necessary by the Laboratory Manager or Project Manager as directed by the customer)

9.4.1 The work order specifies those analy ses necessary to assure compliance with contractual obligations.

9.4.2 The Project Manager or designated personnel under the authority of the Laboratory Manager, are responsible for notifying the Q.A. Manager and performing laboratory departments, through the appropriate supervisor, of all contract requirements including reporting format and quality control criteria. This may be done by reference to other documents (e.g., Purchase Order, statement of work, technical specifications, etc.) that delineates the contract requirements.

9.4.3 The Pro ject Manager or designee under the authority of the Laboratory Manager -, will ensure planning, scheduling, and resources are considered when contracting for or accepting work.

9.4.4 When subcontracting analytical services, the Project Manager or designated individual under the authority of the Laboratory manager-, will assure that:

- The client is notified in writing of the intention to subcontract any portion of the testing to another party.
- If the work is covered under NELAP, the work will be placed with a laboratory accredited under NELAP for the tests to be performed.
- Records, demonstrating that the above requirements have been met, are retained in the project folder.

10.0 PREVENTIVE MAINTENANCE

10.1 POLICY

Preventive maintenance is performed as required on instrumentation and equipment to prevent down time and to ensure reliable performance. The laboratories maintain instrument redundancy that precludes the requirement for a repair and maintenance capability for instrumentation. Maintenance and/or repair of equipment are performed by the equipment manufacturer or authorized representative under contract or purchase order.

10.2 MAINTENANCE

Preventive maintenance procedures will be developed for use where instructions are not provided in the manufacturer supplied operator's manual. As applicable, each department will maintain a major equipment and measurement standards list. A record of instrument maintenance, calibration, and repair, if applicable, will also be maintained. The sup ervisors and operating personnel are responsible for complying with the department maintenance schedule.

10.3 SPARE PARTS

Supervisors will ensure that an adequate inventory of spare parts and consumables is requisitioned and maintained for instrumentation in their area in order to prevent down time or compromise operating conditions.

11.0 CONTROL OF MEASUREMENT AND TEST EQUIPMENT

11.1 MEASUREMENT AND TEST EQUIPMENT CALIBRATION POLICY

This section establishes the controls and calibration requirements for all analyti cal and nuclear measurement equipment. An equipment list will be maintained indicating calibration status.

11.1.1 All equipment whose operation and function directly affect the quality of service will be inspected/calibrated at established intervals. As applicable, equipment will be suitably identified to reflect calibration status. If an instrument is determined to be out-of-tolerance, it will be segregated, or otherwise clearly identified as inoperable. Records of each calibration will be kept in appropriate logbooks or files. Instruments whose calibrations are performed during method operations are calibrated and controlled in accordance with the method requirements. Run logs will be maintained for this category of instrumentation.

11.1.2 The equipment used to determine the quality characteristics and accuracy of instruments will be checked and verified either internally (dependent upon capability), or by qualified calibration services.

11.1.3 Frequency of inspection/calibration will be based on use of the equipment or instrument, environmental conditions in which it is used, its inherent stability, manufacturer's recommendation, and the wear or deterioration resulting from its use.

11.1.4 Certified standards are used for all primary calibrations. National Institute of Standards and Technology (NIST) or NIST traceable, Environmental Protection Agency (EPA), New Brunswick Laboratory (NBL), or Department of Energy (DOE) standards are used, when available, for the primary calibrations or verification of primary calibrations.

11.1.5 All p reparations of standard solutions are recorded in a standards preparation logbook or file. Identities of standards are such that a secondary standard or dilution can be traced, through subsequent actions, back to the initial certification. Records of thes e reference standards are organized in a secure location in the QA office.

11.1.6 Quality control check standards are used to record instrument sensitivity and linearity and to verify proper response. Methods and calibration entries are dated, initialed, and documented by the analyst.

11.1.7 Measuring and test equipment are tagged as to calibration or operating status for periodic processes performed on a scheduled interval of greater than one month. For processes performed more frequently, separate documentation will be available for verification of operational status. Instruments that are too small to be tagged or are subject to a wide variety of calibrations shall have separate documentation of status available.

11.2 RESPONSIBILITY

Testing and/or calibration of equipment and instruments will be performed under the direction of the supervisor, the department manager, or the operations manager and performed under suitable environmental conditions.

11.3 PROCEDURES

All tests and calibrations will be performed in accordance with written procedures that contain provisions for ensuring that all prerequisites for the given test have been met, including appropriate equipment to be used.

11.4 CERTIFICATION AND CERTIFICATES OF CALIBRATION

11.4.1 To the extent possible, calibration will be traceable to NIST. Records of traceability will be maintained along with records of routine calibrations of each instrument or measurement system. Where no NIST traceability exists, the basis used for calibration will be documented.

11.4.2 Equipment records will be main tained to indicate past and current status, and to provide reproducibility and traceability of results.

11.5 RADIOACTIVE SOURCE CALIBRATION

Radioactive sources used as calibration standards will be periodically calibrated and controlled. Current calibration certificates will be kept on file.

11.6 CALIBRATION RECORDS

Supervisors will ensure that calibration data for instruments and radioactive sources is recorded in the instrument logbook, on data work sheets, on computer files and/or control charts. When required, new calibration charts will be prepared when there is measurable change in calibration effect on instruments that have been calibrated. If an instrument is determined to be out of tolerance, it will be segregated or otherwise clearly tagged as inoperable and not used until repaired.

11.7 REPORTS GENERATED FROM USE OF A DEFICIENT INSTRUMENT

If a major deficiency in an instrument or device is detected during periodic calibration procedures, the technician will immediately notify the supervisor, the operations m anager, and the Q.A. Manager. A conference will immediately be scheduled to investigate and decide what corrective action is to be taken on past data and reports resulting from the use of the deficient instrument or device. A record of corrective actions will be maintained.

11.8 PERFORMANCE CHECKS OF RADIATION SCREENING INSTRUMENTS

Performance checks will be made to ensure the continuing capability of radiation screening instruments. Procedures will include efficiency checks and background determinations. Th e procedure and frequency of each check is optimized for each detector system to provide assurance of the detector's performance. Documentation of the checks and the results are kept for all operations.

12.0 DATA REDUCTION, VERIFICATION, AND REPORTING

12.1 USE OF COMPUTER HARDWARE AND SOFTWARE

Computer programs used in the production or support of client data are either purchased, or developed using approved development methodology. Such programs are independently validated, verified, and documented. Changes are controlled to assess the potential impact of the change on the performance of the program.

12.2 DATA REDUCTION AND VERIFICATION

Sample receipt and distribution through the laboratory is documented by the sample receiving technician. Sample handling, subsampling, and preparation for counting measurement are documented by the laboratory technicians.

12.2.1 The successful completion of an analysis is monitored by the Counting Room staff. The Laboratory Manager, or designated individual, performs the final review and approves the data.

12.2.2 Calculation methods, transcriptions, and data flow, plus times and locations of the various tiers of review are detailed in the specific procedure.

12.3 REPORTING

The Project Manager or designated individual is responsible for providing the client with the required analytical results. Reports to clients will be reviewed for accuracy and completeness and, where required, analytical methods and minimum/method detection limits (MDL) will be reported. Laboratory reports of analyses will be signed by an authorized individual who, along with the person who signed the data sheets, can attest to the fact that the data was generated in accordance with established procedures.

13.0 DOCUMENT CONTROL

13.1 POLICY

The primary formal communication methods within the Oak Ridge Laboratory departments are documents that inform or direct activities affecting purchasing, sample analyses and report ing, instrument calibration and/or testing, radiation controls , proper handling of wastes, radiation safety, and Health and Safety. These documents are controlled by the Q.A. Program Manual, Operating Procedure Manuals, other documented procedures, or by interoffice memoranda. Drawings and specifications are not controlled as separate documents but are included in controlled procedures where applicable. The QA Office controls logbooks used to document the analysis of samples (see MP-023, Documentation of Analytical Laboratory Notebooks).

13.2 RESPONSIBILITY

13.2.1 The Q.A. Manager is primarily responsible for maintaining files of all controlled documents and will:

- Review the Quality Assurance Program Manual and provide recommendations for updating.
- Ensure that all holders of controlled documents receive updates to the documents.
- Maintain files of controlled document distribution indicating document title, number, revision number, assigned date, and the name of the individual to whom the document is assigned.
- Forward revisions of controlled documents to assigned individuals. An acknowledgment form will accompany each document revision for verification of receipt and to provide disposition instructions for the superseded pages
- Maintain a Master List o f current procedures which includes procedure number, procedure title, current revision number, and date on which the current revision became effective. The list will be continually updated to reflect all new revisions or new procedures issued. An electronic copy of this list shall be available for employee reference at all times.

13.2.2 Uncontrolled copies of controlled documents will be distributed only if marked "Uncontrolled."

13.2.3 Superseded and/or obsolete documents are isolated from use or destroyed. Upon training to new revisions, employee s sign to verify the destruction of all uncontrolled copies of obsolete revisions.

13.2.4 Each employee is responsible for requesting revisions or changes to operating procedures for their area of responsibility.

13.2.5 The Q.A. Manag er will be advised of any changes in procedures required to satisfy client specific requirements.

13.2.6 Client information and records such as contract requirements, project descriptions, analytical data and results submitted to the client; and all laboratory re cords associated with such submittal will be maintained by the laboratory for a minimum of 5 (Five) years. Clients will be contacted and queried for disposition instructions for their related documentation

13.2.7 If or when the laboratory may transfer ownership, is decommissioned, or goes out of business, ALL clients will be notified and asked to provide specific direction regarding the transfer or disposition of documents and records related to their project(s)

14.0 INTERNAL QUALITY CONTROL

14.1 LABORATORY ANALYTICAL SERVICES

Precautions are taken in the chemistry laboratories to avoid cross-contamination of samples and to ensure the reporting of accurate results. Quality control samples are analyzed along with routine samples to indicate when results may be in error due to improper operation or calibration of equipment, inadequate training of personnel, a deficiency in the procedure, or cross-contamination from other samples.

14.1.1 Laboratory Precision - Laboratory management personnel are responsible to ensure that analytical results are reproduced internally within acceptable limits.

14.1.2 Precision and Accuracy - Replicate standards and/or samples are used to estimate the precision of each analytical test procedure for a known matrix. Data control limits are established to satisfy the requirements of specific measurements based on prior knowledge of the measurement system and method validation studies. Certified standards and/or spiked samples are used to estimate chemical recovery and accuracy for these procedures for known matrices.

14.1.3 Calibration and Performance Checks of Nuclear Measurement Systems - Reference standards are used for calibrating nuclear measurement systems. In addition to calibration of all instrumentation, routine monitoring is performed to ensure the continuing integrity of the instrument performance. The monitoring parameters performed include efficiency checks, background determinations, and energy calibrations. The procedure and frequency of each check is optimized for each detector system to provide assurance of the detector's performance. Documentation of the checks and the results are kept for all systems. The supervisor is responsible for these calibration and performance checks.

14.1.4 Duplicate Analysis - Duplicate aliquots of randomly selected samples will be processed on a routine basis. The analyst will always process samples in accordance within approved operating procedures. The evaluation of the duplicate analysis will be based on examination of the difference between the duplicates. A stat istical analysis of the data may be performed when a cursory evaluation indicates problems with the results. If the two results agree with in the three standard deviation limits, a more detailed evaluation will generally not be necessary. Results of duplica te analyses will be included in the monthly Q.C./Q.A. report.

14.1.5 Detection and Elimination of Bias - Where possible, calibration will be with standards that are traceable to NIST. However, traceability to NIST is not always possible and reliance on other su ppliers may be necessary (e.g., International Atomic Energy Agency, U.S. Department of Energy, U.S. Environmental Protection Agency, or commercial supplier such as Analytics, Amersham Biosciences, AEA Technology, etc.). Standards in the appropriate geometry or form will be used to determine efficiency of instruments on a periodic basis. In the calibration process, the ideal standard will be a known quantity of the radionuclide to be measured, prepared in exactly the same geometry as the samples and counted under the same conditions. In this way, factors such as self -absorption, backscatter, sample geometry, and detector efficiency will be accounted for empirically.

14.1.6 Spiked Samples - A known quantity of calibrated radioactive standard solution will be added to an aliquot of the sample or to a "blank" sample for replicate analysis. When the entire analytical system is operating properly, the laboratory record will demon strate the accuracy and precision of the data. Divergent data from the spiked sample will point out

problem areas. If the data is consistently higher or lower than the known value, bias in the analytical procedure is indicated. This may require a search f or personnel errors, re-standardization of carriers or tracers, and/or recalibration of counting equipment..

14.1.7 Background Determination - The type of equipment and environmental factors contribute to variation in the counting rate of instrument background. The background of each system instrument will be determined and recorded with sufficient frequency to provide a firm statistical basis for that measurement and to ensure response to potential instrument problems or other artifacts such as controlled contamination.

14.1.8 These background determinations will include use of the items that most closely duplicate the analytical configuration in type, geometry, and with any associated fixtures. In some cases, true blanks are not available, but the closest practicable analog is used.

14.1.9 Some systems are sufficiently stable to require no change in backgrounds used for data reduction (e.g., uranium daughter gamma-rays found in gamma spectra due to adjacent building materials and earth). In this case, backgrounds will be compa red to historical data to insure sufficient stability. Other systems experience enough variability to require computed backgrounds based upon running averages.

14.1.10 Background data will be recorded in the logbook or computer file for that specific instrument along with calibration data and instrument maintenance records.

14.1.11 Blanks - Blank samples are routinely analyzed to verify control of contamination and process. Results of processed blanks will be included in the monthly Q.C./Q.A. report.

14.1.12 Collaborative Testing - The Oak Ridge Laboratory participates in collaborative testing or inter-laboratory comparison programs. Natural or synthetic samples prepared to contain known concentrations of certain radionuclides are sent to participating laboratories by an independent referee group such as the DOE Radiological and Environmental Sciences Laboratory DOE, Idaho Falls, Idaho (MAPEP); by a NELAC approved provider such as the Environmental Resources Agency (ERA), Environmental Measurements Laboratory (EML), or by customer(s).

These programs enable Oak Ridge Laboratory personnel to document the precision and accuracy of radioactivity measurements, identify instrumental and procedural problems, and compare performance with other laboratories.

14.2 QUALITY CONTROL AND DATA REPORTS

14.2.1 Quality Control Reports

Quality control results will be summarized, and include with every sample/group of samples.

14.2.2 Data Reports

Routine performance requires documentation of all pertinent information with the basic documents dated and initialed or signed. Required documentation will be the initial work order, Chain-of-Custody (CoC), or document that records all pertinent information such as the identity of the sample and analyses to be performed. The data report will include technic al analysis notes, logbooks, work sheets all raw data and other information used in performing the analysis. The report of analysis will be the final report of the data to the client and is issued in accordance with the laboratory's procedure for review and processing, as well as any client specific requirements.

14.3 DATA VERIFICATION

Routine performance requires inclusion of all pertinent information with basic documents dated and initialed or signed. The work order has recorded such information as the ident ity of the samples and analyses to be performed. All raw data and other information used in performing the

analyses are documented.

14.3.1 Electronic Deliverables Verification - Project managers, or designated individuals, are responsible for ensuring that electronic deliverables are complete and accurate.

14.4 Sample Custody

Samples are assigned a unique laboratory identification number, marked on a label that is applied directly t o the container and which identifies the work order and laboratory fraction. Sample control personnel are designated sample custodians for strict (legally defensible) CoC samples. Locked buildings, refrigerators, freezers, and cabinets are available for Co C samples. Sample custody forms or technician analysis notes are used for tracking all samples through the analytical process. Details for radiological survey of samples, sample security, sample disposal, etc. are outlined in approved Sample Control Procedures. Sample chemistry and nuclear counting requirements are assigned by the laboratory manager, or designated individuals.

15.0 AUDITS

15.1 POLICY

The Oak Ridge Laboratory has established a comprehensive system of planned and documented audits to verify compliance with all aspects of the Q.A. Program. An audit is defined as a documented activity performed in accordance with written procedures or checklists to verify, by examination and evaluation of objective evidence, that applicable elements of the Q.A. Program have been developed and effectively implemented in accordance with specific requirements. Audits will be performed by persons not having direct responsibility for those areas being audited.

15.1.1 Customer Access to the Oak Ridge Laboratory Facilities and Personnel - The client is frequently responsible for auditing the Oak Ridge Laboratory's performance relative to contractual requirements. The exact nature of this responsibility is relative to the nature of the regulatory or licensing requirements, the significance of the services, and the technical expertise available or inherent within the client's organization. The need for, and frequency of, client audits is dependent upon the above factors. A client may authorize an independent agency to perform an audit on its behalf. When possible, the facilities, equipment, and records (proprietary information excluded) of the Oak Ridge Laboratory will be made available for client inspection along with the necessary personnel to permit verification of quality characteristics.

15.1.2 The Q.A. Manager will coordinate and participate in audits conducted by the client or the client's representative.

15.1.3 Internal Audits - The Q.A. Manager will audit the laboratory operations to verify compliance with established procedures and requirements set forth in the Q.A. Program Manual. Use of a checklist will insure items in compliance are noted as well as any requirements for improvement.

15.1.4 External Audits - External audits of organizations providing services to the Analytical Services Group are scheduled at a frequency commensurate with the status and importance of the activity.

15.2 RESPONSIBILITY

Audits will be directed by the Q.A. Manager with assistance from designated personnel.

15.2.1 The Q.A. Manager will be responsible for an independent quality assurance audit of each department.

15.2.2 The Q.A. Manager will be responsible for assuring that audits are performed by knowledgeable professionals.

15.2.3 An independent qualified auditor will audit areas of responsibility assigned to the Q.A. Manager.

15.3 DOCUMENTATION

Audit results will be documented by the Q.A. Manager.

15.3.1 The Laboratory Manager shall be provided a copy of the audit report.

15.3.2 The QA Manager will determine if there are any corrective actions required and the individual responsible for implementing the corrective action

15.4 DEFICIENT AREAS

15.4.1 The responsible Manager will ensure correction of the identified deficiencies.

15.4.2 The Q.A. Manager will verify that action is taken to correct any deficiency and will take follow-up action to ensure that corrections have been completed.

15.4.3 The Q.A. Manager will ensure close out, with documentation, of the audit after corrective actions have been completed.

15.4.4 For uncorrected or unresolved deficiencies, after due diligence, the Q.A. Manager will petition the Laboratory Manager to bring to bear his authority for resolution of the deficiencies.

15.5 FREQUENCY OF AUDITS

The Q.A. Manager will ensure internal audits are conducted on an annual basis. Additional selective audits will be conducted when one or more of the following conditions exist:

15.5.1 When significant changes are made in functional areas of the Q.A. Program, including significant reorganization or procedure revisions.

15.5.2 When assessment of the Program's effectiveness is considered necessary.

16.0 QUALITY ASSURANCE AND INSPECTION RECORDS

16.1 POLICY

Records that provide objective evidence of the quality of work are generated and maintained. These records include controlled logbooks, customer instructions, sample analyses data sheets, and results of reviews, inspections, tests, audits, corrective actio ns, reports, and training records. Also included are related data such as personnel qualifications, procedures, and equipment records.

16.2 RESPONSIBILITY

The responsibility for initiation, completeness, and reliability of Q.A. records is vested in the appro priate supervisor, with periodic verification checks by the Q.A. Manager. All Oak Ridge Laboratory personnel performing processes or services associated with the work being performed will assist in the efforts.

16.3 RECORDS

16.3.1 Inspection and test records will, at a minimum, identify the inspector or data recorder, the type of observation, the results, the action taken in connection with any deficiencies noted, and the date of the inspection or test.

16.3.2 All required records will be legible and of a quality that can be copied. Records shall be completed using reproducible ink. Errors or incorrect entries will be lined through with a single line, dated, and initialed by the recorder.

16.3.3 Correspondence from clients may be made available for inspection at the discretion of client representatives and authorization from the originating organization.

16.3.4 Q.A. records will be identified and controlled by customer number and/or client identification as applicable.

16.4 STORAGE OF RECORDS

16.4.1 Quality assurance records will be firmly attached in binders, placed in folders or

envelopes, and, if applicable, cross referenced by client identification and stored in a secure area.

16.4.2 Q.A. records will be properly stored and made available to the client upon request.

16.4.3 Records will be maintained in a secured and protective storage area.

16.4.4 Records will be identified and be retrievable.

16.4.5 CoC records are included with the sample set records.

16.4.6 Longer retention or duplication of records is available at the specific direction from the client.

16.4.7 Laboratory management will be responsible for governing access to, and controlling the records.

16.4.8 Analytical reports and source calibration data will be retained for a minimum of five years after results are reported to the client.

16.4.9 Procurement records will be retained for a minimum of five years or as required by the contract.

16.4.10 All records and analyses performed pertaining to (NELAC) accreditation will be kept for a minimum of 5 years and would be available for inspection by the accrediting authorities during this period even without prior notification to the laboratory.

17.0 CORRECTIVE ACTION

17.1 POLICY

The Oak Ridge Laboratory policy is to ensure continuous acceptabl e quality levels for services provided. Conditions adverse to quality will be identified and corrected as soon as practical.

17.2 CORRECTIONS

17.2.1 CORRECTIVE ACTION REPORT (CAR)

In the case of a significant condition adverse to quality, the cause of the condition shall be determined and corrective action taken to preclude recurrence. The identification, cause, and corrective action shall be documented and reported to appropriate levels of management. Follow-up action shall be taken to verify implementation of this corrective action and documented via a Corrective Action Follow -Up form. The Corrective Action Report (CAR) Form shall be used to document this condition. Typically, the Q.A. Manager will initiate investigation and corrective action by issuing a Corrective Action Report (CAR) in any of the following situations:

- When an audit reveals circumstances that will adversely affect quality (Audit Finding) as determined by the Q.A. Manager.
- When any results of an inter-comparison study are out of control, or for non-participation.
- When procedural or technical problems arise and the Q.A. Manager determines that they will significantly affect quality.

17.3 NON-CONFORMANCE REPORT (NCR)

A non-conformance is a deficiency in a characteristic, procedure, or documentation that renders the quality of an item unacceptable, however, is not considered a significant condition that would require an investigation by use of a CAR. In the laboratory,non-conformances can include physical defects, incorrect or inadequate documentation, and deviations from an established protocol, plan, or documented technical requirement. This condition is documented using a Non-Conformance Report (NCR) Form.

17.4 RESPONSIBILITY

All laboratory personnel are responsible to communicate any evidence of unacceptable quality performance to their supervisor, the responsible manager, and/or the Q.A. Manager.

17.4.1 The responsible manager will ensure investigation of a condition adverse to quality, determine assignable cause, and provide recommendation(s) for corrective action.

17.4.2 The responsible manager will ensure action is initiated to correct the assignable cause of the adverse condition and to determine and initiate the specific corrective action(s) necessary to preclude recurrence.

17.4.3 The Q.A. Manager will review CARs, NCRs, and routine Q.C. reports for evidence of unacceptable quality.

17.4.4 Copies of the completed CARs and NCRs will be kept on file by the Q.A. Manager.

17.5 CLIENT NOTIFICATION

The client will be notified when any Corrective Action is initiated due to evidence of unacceptable quality that is related to their contract.

18.0 QUALITY ASSURANCE REPORTS TO MANAGEMENT

18.1 POLICY

The Oak Ridge Laboratory policy is to keep management apprised of all quality assurance problems, actions taken to correct them, and any actions taken to prevent recurrence.

18.2 QUALITY ASSURANCE REPORTS

18.2.1 Quality Assurance Reports are prepared quarterly by the QA Manager and submitted to upper management. The reports shall in clude discussion of inter-comparison studies, status of corrective actions, and quarterly QA objectives

18.2.2 The Q.A. Manager will report all general or system audit results, problems, corrective actions, and replies.

Document Revision History

Revision	Effective Date	Changes From Previous Revision
7	8/1/13	· Document Revision History table implemented · Added Emergency Coordinator to title designations of positions in Section 1.4.4 · Updated list of accreditations in section 1.9 to reflect all current certifications · Updated Laboratory Organization Chart · Removed requirement for employees to maintain hard copies of procedures in work area.